In this Issue: The Ozone Process of Water Purification—Day Labor vs. Contract Work: Experience in New England and in California—European Testing Laboratories—An Instrument for Measuring Acceleration

ENGINEERING NEWS

Founded 1874.
Volume 63. No. 17.

220 Broadway, NEW YORK, THURSDAY, APRIL 28, 1910.

$5.00 per Year.
Single Copies, 15 Cents

Buyers' Reference, Page 35

Alphabetical Index of Advertisers, Page 39

GENUINE
Manganese Steel
Parts for all makes of crushers, as
JAWS, CHEEKS, TOGGLES and BEARINGS
Concaves, Wearing Plates, Heads, etc.
STEAM SHOVEL TEETH, POINTS and BASES
Lips for Gold Dredges and Steam Shovel Dippers
Chutes, Grizzlies, Pins, Bushings, etc.
Beveland Spur Gearing for Steel Mills, Cement Plants
KOMINUTER PLATES
Revolving Screens or Trommels
Mine Car Wheels Roll Shells Grizzly Bars
AMERICAN BRAKE SHOE AND FOUNDRY CO.
30 Church St., New York — Western Union Bldg., Chicago

ALLIS-CHALMERS COMPANY
POWER AND ELECTRICAL MACHINERY
General Offices - Milwaukee, Wisconsin

SMITH MIXER
SYMONS CRUSHERS
See our advertisement on page 61

"The best not the cheapest."
Our "Data" tells all about
"BESSEMER PAINT"
Sole Manufacturers
RINALD BROTHERS
1142-1146 N. Hancock Street, Philadelphia

HIGH DUTY PUMPING ENGINES
Vertical Triple Expansion and Horizontal Compound
THE WILLIAM TOD COMPANY, Youngstown, Ohio

HEALY PLACES
THE CAMERA RIGHT FOR
Industrial Photographs
Then the negative is as good as the viewpoint
649 Summit Avenue, Jersey City, N. J.
Erie R.R. Studio — Tel., 2405 Jersey City

Foundry Equipment
WHITING CRANES, CUPOLAS, LADLES, TUMBLERS, TRUCKS, TURNTABLES, ETC.
Complete Equipments
Gray Iron, Malleable, Steel, Brass, Car Wheel and Pipe Foundries
WHITING FOUNDRY EQUIPMENT COMPANY Harvey Ill.

THE RECOGNIZED STANDARD
SEWER PIPE
ALL SIZES
ALL SHAPES
VITRIFIED GLAZED CLAY
WRITE US NOW
EVENS & HOWARD FIRE BRICK CO., St. Louis, Mo.

For Interesting and Valuable
INFORMATION
About
Cunningham Coal Tar Paint
Address the
MARYLAND STEEL CO.
Sparrow's Point, Md.

Dr. Chas. F. McKenna
CONSULTING CHEMIST AND CHEMICAL ENGINEER
Specializing in Qualities of Materials
INSPECTION—PROCESSES OF MANUFACTURE—RESEARCH
50 Church Street - New York City.

BLACKMER & POST PIPE CO.
ST. LOUIS
Vitrified Pipe Exclusively
LARGE SIZES A SPECIALTY

STEEL TANKS
Tower Tanks Tank Cars
Standpipes Vats and Kettles
THE KENNICOTT COMPANY
Chicago Heights, Ill.
CHEMISTS ENGINEERS MANUFACTURERS

"Lehigh" Portland CEMENT
High Tensile Strength Finely Ground
Light and Uniform in Color
Recommended for High Class Engineering Work
Manufactured by
LEHIGH PORTLAND CEMENT CO.
ALLENTOWN, PA.
Western Office
725 Rockefeller Building Cleveland, Ohio

Permanent Impervious
3 inch to 36 inch
Standard and Double Strength
Vitrified Salt-Glazed Sewer Pipe
The SANITARY Sewer Material
W S DICKEY CLAY MFG CO
Kansas City Mo

1896 HIGH GRADE 1896
"PIONEER" ASPHALTS
used with unqualified success since 1896
See our advertisement on pages 2 and 3
THE AMERICAN ASPHALTUM & RUBBER CO.
600-614 Harvester Building, Chicago

LOOMIS FILTERS
Improved System — Established 1880 — Results Guaranteed
LOOMIS-MANNING FILTER DISTRIBUTING CO.
Main Office, 828 Land Title Bldg., Philadelphia, Pa.
New York Boston Baltimore Washington Buffalo Chicago

MACOMB SEWER PIPE CO. MACOMB, ILL.
Superior Vitrified Sewer Pipe — Double Strength Extra Thick Culvert Pipe

GOODRICH
CONVEYOR BELT
Improved Method of Construction.
Write for special literature.
The B. F. Goodrich Company,
Akron, Ohio
See our advertisement on page 68

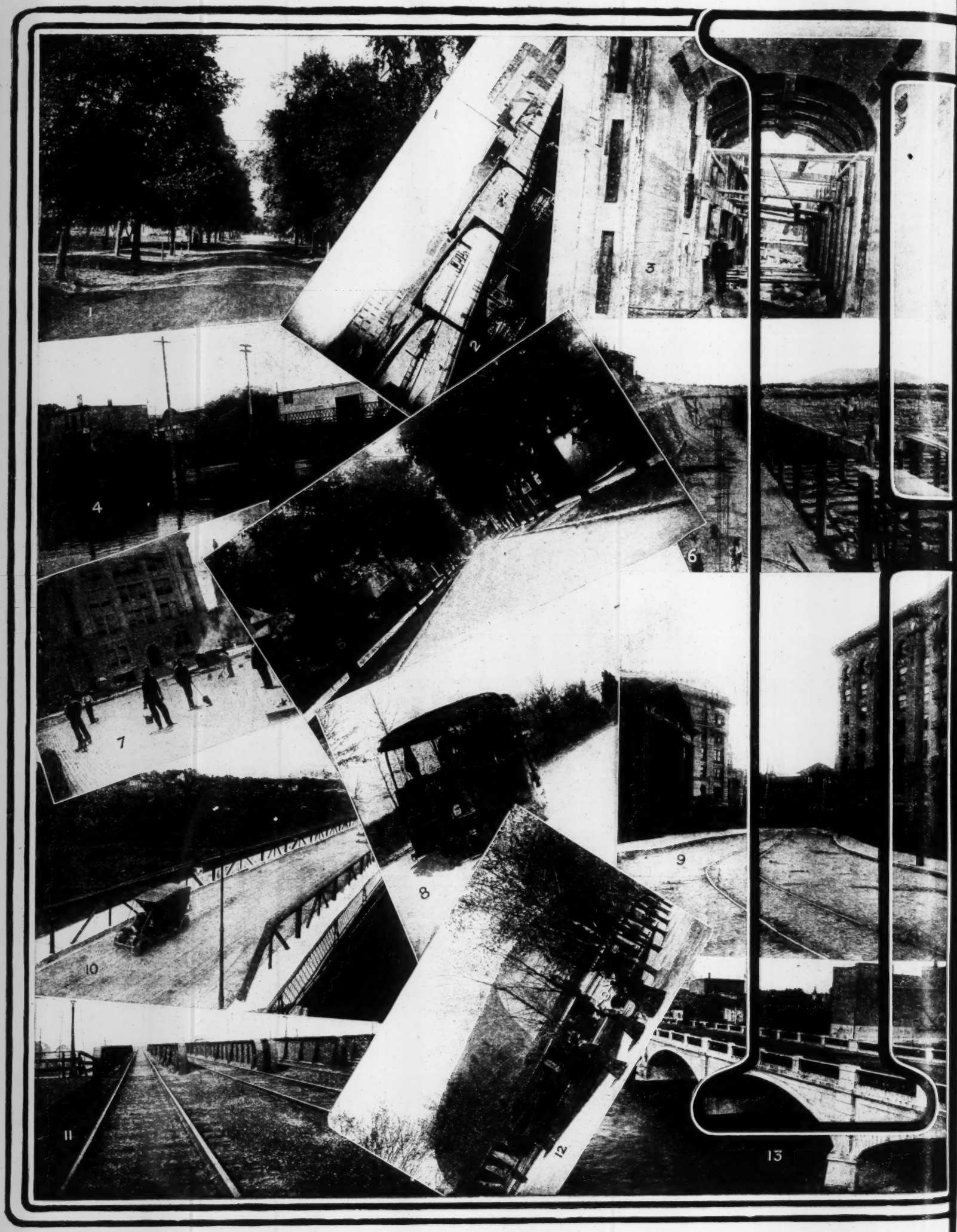
LATROBE FLANGES
Soft Steel Weldless Flanges
Forged and Rolled from
SOLID STEEL INGOTS
Suitable for High-Pressure Steam, Water or Gas Line
For Details as to Prices, etc., address
RAILWAY STEEL-SPRING CO.
General Offices
Cortlandt Bldg., 30 Church Street, New York

SARCO
MINERAL RUBBER PIPE COATING
Maximum Protection Proved Value
SARCO
No. 6 WATERPROOFING
Permanently protects any character of construction from damage by water
INQUIRIES SOLICITED
STANDARD ASPHALT AND RUBBER COMPANY
205 La Salle Street, Chicago

Will Furnish and Erect in
United States and Foreign Countries
Wooden Stave Pipe
EXCELSIOR WOODEN PIPE CO.
San Francisco
Advertisement is on page 15

ALL SIZES
Monmouth Sewer Pipe
Made by
MONMOUTH MINING AND MFG. CO.
Monmouth, Ill.

MAKE TIGHT STEAM JOINTS BY USING CORRUGATED **COPPER GASKETS** FOR FLANGED PIPES CYLINDERS, CHESTS, Etc.
Samples and Circulars free
UNITED STATES MINERAL WOOL CO., 140 CEDAR STREET, NEW YORK CITY



Views Showing Various Uses of "Pioneer" Asphalt Materials.

1. Macadam road near Columbus, Ohio, Waterproofed with "Pioneer" Road Asphalt.
2. Bridge at Saginaw, Mich., "Pioneer" Filler Asphalt used in joints of creosoted wood blocks.
3. Washington Street Tunnel, Chicago, waterproofed with "Pioneer" Waterproofing Asphalt.
4. Bridge at Janesville, Wis., paving brick filled with "Pioneer" Filler Asphalt.
5. "Pioneer" Sheet Asphalt pavement, Bay City, Mich.
6. 10,000,000-gallon reservoir at Monterey, Mexico, waterproofed with "Pioneer" waterproofing asphalt.
7. Applying "Pioneer" Filler Asphalt on brick paving.
8. Macadam Road near Atlanta, Ga., bound and waterproofed with "Pioneer" Road Asphalt.
9. Carnegie Library, Ft. Worth, Texas, "Pioneer" Filler Asphalt used in street paving.
10. Viaduct, Joplin, Mo., painted with "Wasatch" Structural Paint.
11. Railroad bridge, Gary, Ind., waterproofed with "Wasatch" Mastic.
12. Tabernacle, Salt Lake City, Utah, "Pioneer" Mineral Rubber Roofing Cement.
13. Concrete bridge, Waterloo, Iowa, waterproofed with "Pioneer" Mineral Rubber Paint.

ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 63. No. 17. 220 Broadway, New York, April 28, 1910.

TABLE OF CONTENTS.

LEADING ARTICLES: Page.

A Comparison of Stream Discharges Indicated by Current Meter and by Weir Formulas, Yakima River, Washington (illustrated); J. C. Stevens, Assoc. M. Am. Soc. C. E. 481

Notes on the Proposed Sewage Disposal Plant for Gloversville, N. Y.; Morrell Vrooman, Assoc. M. Am. Soc. C. E. 482

The Stadia and Stadia Surveying (illustrated); E. M. Douglas, M. Am. Soc. C. E. 483

Notes on Some European Testing Laboratories; [Contributed] 484

The New Dock Facilities at Avonmouth, Eng. (illustrated) 486

The Production and Utilization of Ozone, with Special Reference to Water Purification (illustrated) 488

An Instrument for Measuring Acceleration and Gradient (illustrated) 496

Some Views on the Chicago Harbor Problem 501

The Discharge of Sewage Into the Hudson River 502

The Massachusetts State Board of Health Report on a Mechanical Filter Plant for Lynn, Mass. 503

Relative Efficiency of the Day-Labor and Contract Systems of Doing Municipal Work 504

Some Los Angeles Aqueduct Costs 504

One Month's Operation of the Cleveland, Ohio, Ry., Under Three-Cent Fares 505

A Portable Stone Crushing and Concrete Mixing Plant for Street Railway Work 505

EDITORIAL 497

Oil-Shales as a Future Source of Supply for Petroleum—The Chicago Problem. The Commercial Utilization of Ozone for Water Purification and Other Purposes 497

LETTERS TO THE EDITOR 499

The Use of Curve Radii Based on Two 50-Ft. Chords; C. M. Kurtz—The Duty of Pumping Engines; Chas. A. Hague—Some Mooted Points in Reinforced Concrete Design; Alexis Saurbrey—The Passage of Pathogenic Bacteria Through Sand Filters; Rudolph Hering, M. Am. Soc. C. E.—Notes and Queries.

ENGINEERING NEWS OF THE WEEK 507

PERSONALS 508

ENGINEERING SOCIETIES 508

A Comparison of Stream Discharges Indicated by Current Meter and by Weir Formulas, Yakima River, Washington.

By J. C. STEVENS,* Assoc. M. Am. Soc. C. E.

A rather interesting comparison has recently been secured at the gaging station on Yakima River, near Wapato, between results secured with a current meter and those obtained by formula for an overflow dam.

The gaging station is maintained by the U. S. Geological Survey in co-operation with the U. S. Reclamation Service. It owns and operates the Sunnyside Canal which diverts water from Yakima River at this point. The diversion dam (Figs. 1 to 3) is of ogee section, 500 ft. in length on the crest. The crest is 7.5 ft. above the overflow apron. There is a sluiceway in the dam 6 ft. wide and 7 ft. deep. During the low-water period this sluiceway is closed by flash boards. At the left end of the dam are controlling gates for diverting water into the Sunnyside Canal. In the forebay above these gates, a hook gage has been installed, which indicates the head of water flowing over the dam. About 1,000 ft. below the dam a gaging station has been installed where measurements are made from a car and cable. A chain gage operated on a cantilever beam has been installed at the cable section. The discharges measured at the cable are those passing over the diverting weir. During the season of 1909, twenty discharge measurements were made from the cable, and each measurement has been referred to both the chain gage at the cable section and hook gage at the diversion dam.

It was thought that the hook gage would be a stable index of the discharge, since it indicates the head of water passing over the dam, and, once the coefficients were determined, it was believed that no additional measurements would be required. How well our assumptions in this respect were fulfilled is well illustrated by the accompanying diagram (Fig. 3). Three discharge curves are shown, one for the gaging station wherein the discharges obtained by current meter have been referred to the gage heights from the chain gage at the cable at the time of measurement. The other discharge curve is for the diversion dam, wherein the same discharge measurements are plotted with the gage heights observed on the hook gage as coordinates. The lower portion of each curve is represented separately on an enlarged scale, and is marked "Low Water Curve." Those for the dam represent theoretical discharges with "Sluiceway Open" and "Sluiceway Closed." It will be noted that the measurements referred to the chain gage fall very consistently on the discharge curve, while those referred to the hook gage are much more scattered.

The accompanying table gives the results of the discharge measurements referred to both the chain gage and the hook gage, and the coefficients for discharge over the dam for the formula

$$Q = C\,L\,H^{3/2}.$$

In determining the coefficient for discharge over the dam with sluiceway open, the discharge through it has been deducted and the length of dam considered as 494 ft. The measurement of

*District Engineer, U. S. Geological Survey, Tilford Bldg., Portland, Ore.

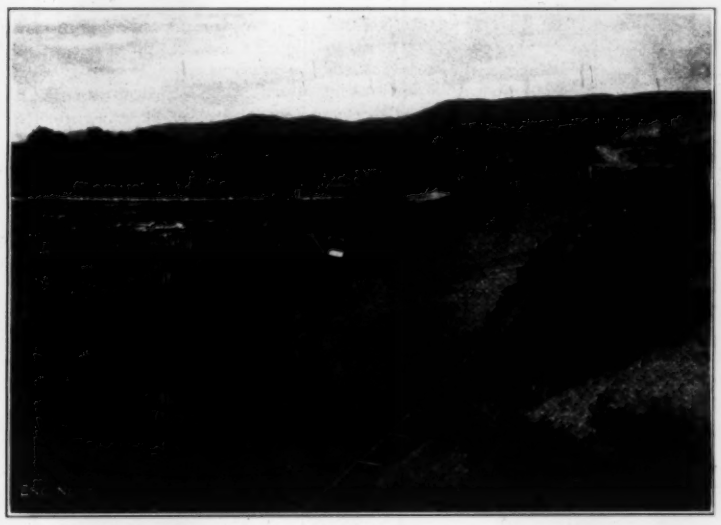


Fig. 1. April 23, 1909, With 1.43-Ft. Head of Water.

Fig. 2. June 14, 1909, With 3.1-Ft. Head of Water.

FIGS. 1 AND 2. DIVERSION DAM, YAKIMA RIVER, NEAR WAPATO, WASH.; SUNNYSIDE IRRIGATION PROJECT.

(Published by permission of the U. S. Reclamation Service.)

DISCHARGE MEASUREMENTS OF YAKIMA RIVER, NEAR WAPATO, WASH., 1909.

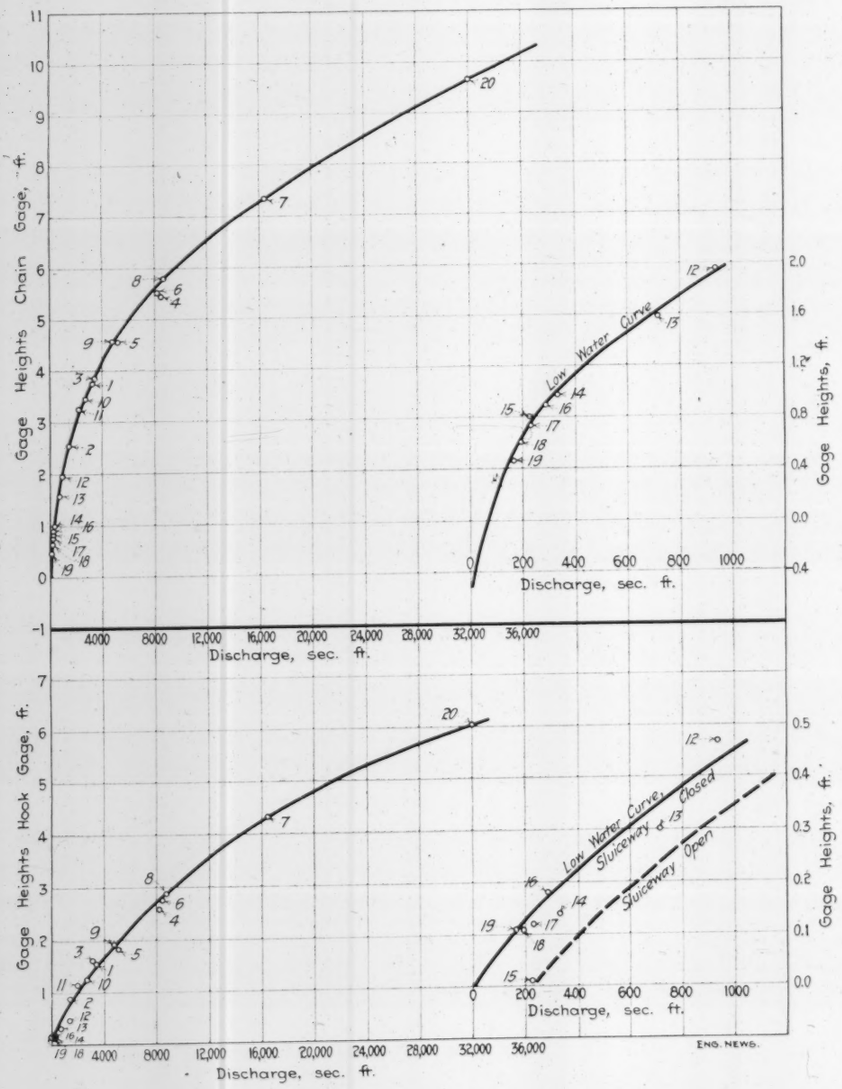
No.	Date (1909)	Width	Area of section sq. ft.	Mean velocity ft. per sec.	Discharge cu. ft. per sec.	Gage height ft. Chain gage.	Gage height ft. Hook gage.	Coefficient (C.)
1	Jan. 22	272	1,320	2.44	3,210	3.78	1.59	2.97
2	Feb. 16	270	974	1.49	1,440	2.53	.88	2.92
3	Feb. 16	275	1,330	2.44	3,250	3.82	1.55	3.16
4	May 4	288	1,930	4.35	8,400	5.46	2.76	3.58
5	May 12	280	1,540	3.23	4,980	4.54	1.85	3.78
6	May 26	288	1,910	4.29	8,220	5.50	2.57	3.90
7	June 3	302	2,420	6.81	16,420	7.35	4.33	3.62
8	June 18	288	1,870	4.65	8,720	5.78	2.87	3.52
9	June 25	280	1,520	3.15	4,790	4.53	1.90	3.48
10	July 13	273	1,210	2.28	2,760	3.45	1.23	3.71
11	July 14	272	1,140	1.96	2,240	3.25	1.12	3.41
12	July 23	269	808	1.16	939	1.96	0.47	4.35
13	July 31	266	710	1.01	719	1.59	0.30	5.91
14	Aug. 10	264	549	0.61	336	0.98	0.14	4.04
15	Aug. 13	265	502	0.45	225	0.80	0.20	....
16	Aug. 23	264	529	0.55	290	0.98	0.18	7.62
17	Sept. 4	265	470	0.48	229	0.74	0.12	10.90
18	Sept. 6	262	457	0.41	191	0.61	0.11	10.60
19	Sept. 25	252	428	0.39	164	0.46	0.11	9.12
20	Nov. 24	303	2,970	11.10	32,000	9.65	6.05	4.30

Aug. 15 indicates the amount passing the sluiceway. It was closed from Aug. 14 to Nov. 1.

It will be noticed that the general tendency is for an increase in the coefficient as the head increases. The coefficients for heads less than 0.2-ft. are inordinately large. This is probably due to the fact that the crest of the dam is not absolutely level. Elevations of its crest were determined at 5-ft. intervals, and the mean elevation used in setting the hook gage. A variation of about 0.2-ft. was observed between the highest and lowest points on the crest.

At all stages the head of water is affected more or less by driftwood, which invariably lodges on the crest of the dam. It is believed that this is a partial explanation, at least, of the inconsistency of the measurements when referred to the hook gage. At each freshet the area on the crest of the dam obstructed by driftwood is changed so that the head of water is not always a stable index of discharge.

Fig. 1 and 2 show the dam under different conditions as regards this feature of driftwood. They were taken within seven weeks of each other.



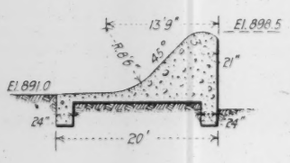


FIG. 3. DISCHARGE CURVES FOR CABLEWAY GAGING STATION AND FOR DIVERSION WEIR, AT WAPATO STATION, YAKIMA RIVER; SUNNYSIDE IRRIGATION PROJECT, WASHINGTON.

Notes on the Proposed Sewage Disposal Plant for Gloversville, N. Y.

By MORRELL VROOMAN*, Assoc. M. Am. Soc. C. E.

After some two years of experimental work to determine the best means of treating the sewage of Gloversville, N. Y., the city let a contract for disposal works in December, 1909. The sewage presents unusual difficulties on account of the large amount of tannery wastes which it contains. On this account and also because of the small dry-weather flow of the creek into which the effluent will be discharged the sewage will be screened, passed through primary settling tanks, sprinkling filters, secondary settling tanks and sand filters. The following notes outline the nature, dimensions and capacity of the various parts of the plant and the proposed method of operation.

The plant consists of valve and screen chamber, two circular vertical flow primary settling tanks, one dosing tank, 3.07 acres of sprinkling filters, two secondary vertical flow settling tanks, 2.75 acres of sludge beds, 2.71 acres of sand filters.

SCREEN CHAMBER.—The screen chamber is rectangular in form, about 12 ft. sq. and 6 ft. deep, constructed of reinforced concrete. It is in no sense a grit chamber. It will contain a screen of flat iron bars, spaced 1⅛ ins. apart.

PRIMARY SETTLING TANKS.—The vertical flow primary settling tanks are two in number, circular in form, having a conical bottom. The cylindrical part is 36 ft. 4 ins. in diameter at the top, 35 ft. at the base and 31 ft. deep. The conical bottom is approximately 18 ft. deep. Each tank will contain 48 ft. of sewage. The tanks have a wooden inlet trough connected by a 3-ft. wooden pipe to a distribution cone, 18 ft. 6 ins. in diameter, 31 ft. down from the top of the tank. There are four collector troughs at the surface of the tank. For the removal of the sludge, there is a 10-in. cast-iron pipe from the bottom of the cone of each tank, which is operated by valves under either a 1-ft. or 6-ft. head of sewage in the tanks, which will deliver the sludge to the sludge beds by gravity. These tanks are connected with a dosing chamber planned to give a variable head from 0 to 5 ft. on the sprinkling nozzles, and of such shape as to give nearly a uniform quantity of sewage on the area covered by the nozzles.

SPRINKLING FILTERS.—The sprinkling filters are to be constructed of reinforced concrete. They will contain 5 ft. in depth of crushed stone, varying in size from 1½ to 2½ ins. There will be 930 sprinkling nozzles, giving a square distribution. The sewage is to be delivered to the nozzles by cast-iron risers through 6-in. vitrified tile distribution pipes, connected with three reinforced-concrete distribution mains beneath three longitudinal flushing and inspection galleries of reinforced concrete built in the filters, with flushing ports at the end of each lateral underdrain. The underdrainage system is to consist of either (1) concrete channels, covered by 1 × 3 × 16-in. slabs, on which the stone are placed or (2) of a concrete floor with 6-in. half-tile underdrains, slotted at the sides, spaced 3 ins. apart. The underdrain laterals end in four longitudinal underdrain collectors, which empty in a main collector connected with the secondary settling tanks.

The sprinkling filters will be covered during the winter with rough plank, supported by reinforced-concrete beams and columns. The roof will be removed during the warmer months.

SECONDARY SETTLING TANKS.—The secondary settling tanks are the same in design as the primary tanks, except that their cylindrical portion is 11 instead of 31 ft. in depth, and that the sludge will flow into a circular pump well 12 ft. in diameter, and will be pumped by a 6-in. centrifugal pump to the sludge pipe and thence flow by gravity to the sludge beds. The sludge beds are constructed by removing the sod and using the natural gravel without underdrainage, and adding gravel where necessary to make the beds level. The embankments will be of the material stripped from the surface.

SAND FILTERS.—The sand filters will be 4 ft. in depth, of coarse sand obtained by selection or by screening and washing, and will be underdrained by 6-in. circular vitrified pipe 20 ft. c. to c., with open joints surrounded by 1½ ft. of coarse screened gravel.

OPERATION.—The sewage from the main sewer will enter the screening chamber, from which it will pass to the two sedimentation tanks. With an average flow of sewage of 3,000,000 gals. per day, the velocity of sewage in the vertical tanks will be 8.65 ft. per hr., and the time of passing through the tanks 3.47 hrs. With a maximum sewage flow at the rate of 5,000,000 gals. per day, the velocity will be 14.5 ft. per hr. and the period in the tank 2.07 hrs.

The dosing tank will have automatic apparatus that will be capable of dosing the sprinkling filters at a maximum rate of 10,000,000 gals. per day.

The distribution system and nozzles in the sprinkling filters will care for the sewage at the maximum rate of 10,000,000 gals. per day, and the filters are planned to operate under an average of 1,000,000 gals. per acre per day.

The effluent from the sprinkling filters will pass into the two secondary tanks. With an average flow through the vertical tanks at the rate of

*City Engineer, Gloversville, N. Y.

3,000,000 gals. per day, the rate will be 8.65 ft. per hour, with a period in the tank of 1.16 hrs. At a rate of flow of 5,000,000 gals. per day, the velocity will be 14.5 ft. per hr., and the period in the tank 0.69 hrs.

From the secondary tanks the sewage will flow to the sand filters, on which it will be treated at a rate a little in excess of 1,000,000 gals. per day.

The effluents from these sand filters will flow into the creek. The sludge will be permitted to dry on the sludge beds and will then be deposited on sandy soil, in the vicinity of the plant, and on land owned by the city.

Mr. Harrison P. Eddy, M. Am. Soc. C. E., of Metcalf & Eddy, Boston, Mass., is consulting engineer. The contractor for the plant is Mr. Albert L. Willey, of Binghamton, N. Y.

The Stadia and Stadia Surveying.

By E. M. DOUGLAS,* M. Am. Soc. C. E.

It is with the hope of increasing the popularity of a very useful engineering device that the following notes on the stadia are written. For more than twenty years the writer has missed no opportunity for recommending the stadia for distance measurements where extreme accuracy was not required, and he has yet to find a single person who after giving it a fair trial did not speak in its favor. The stadia has been used in the United States for more than 50 years, but there still seems to be a widespread belief that it is at best but a very crude method for determining distances.

Numerous comparisons between stadia measurements and measurements by chain, steel tape or triangulation have been made by various public organizations as well as by private individuals, with results that show that for ordinary stadia work errors should not average more than 1:600 while for work of a high grade the errors may range from 1:1000 to 1:5000 or even less. It is true that for a single short line there may be an error much larger than 1:600, but since plus and minus errors tend to balance for long lines, the relative accuracy of measurement increases with the length of the line.

The following table gives the length and ratio of errors for various lines. It will be noticed that the ratio of errors varies greatly for the Mexican boundary work. The reason for this is that the work was carried on under very unfavorable conditions, some of them as bad as will ever occur in actual practice. Chain measurements over parts of the same lines gave errors as compared with triangulation ranging from 0 to 1:827 with a mean of about 1:1440. This good result for the chain occurred only after six errors of an entire chain length each were discovered by comparison with the stadia distances for the same lines; had these errors not been eliminated the mean chain error would have been about 1:520. For some portions of the Mexican boundary line the conditions for chaining were so unfavorable that measurements by that method were not attempted, stadia checked by triangulations alone being used.

ERRORS OF STADIA MEASUREMENTS.

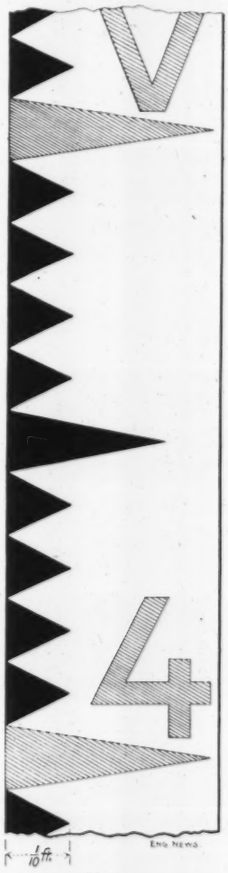
	Authority.	Number of lines.	Length, miles.	Error.
1	Lake Survey.....	141	1½	1:648
2	St. Louis Survey.....	1	22	1:930
3	Idaho Boundary.....	1	65	1:2560
4	Mexican Boundary.....	1	122.3	1:2850
5	" "	1	13.2	1:765
6	" "	1	8.1	1:600
7	" "	1	13.5	1:700
8	" "	1	14.0	1:3214
9	" "	1	61.1	1:1116*
10	" "	1	670	1:2200
11	Land Survey.....	5	36	1:2850
12	Land Survey.....	2	36	1:8040

*Corrected chain error 1:1373.

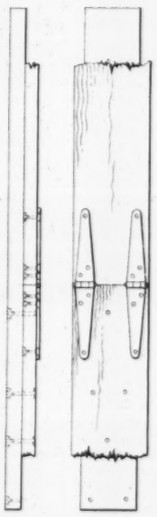
Good stadia work is dependent on several factors besides the skill of the observer; the instrument, the rod, the value adopted for the cross wire interval, and the conditions under which the work is carried on are all influential.

For the sketching of topography, as in ordinary map work, a telescopic alidade used in connection with a plane table is the best; for traverse, for the subdivision of land or for railroad reconnaissance surveys, an engineers' transit fitted with a vertical circle is the instrument recommended. With either instrument a good telescope is essential; this should have a first-class object glass, accurately ground, with a clear aperture of not less than 1 in. and not necessarily over 1¼ ins. The eyepiece should be direct and have a magnifying power of about 20 to 25 diameters.

There should be four cross wires of spider web or platinum. Lines ruled on glass are often used, but they collect dust and moisture and absorb considerable light. Three of the lines should be parallel and at equal intervals apart; the fourth, the vertical wire, should be at right angles to the others. These should all be fixed in position on the cross wire ring and adjusted by moving the entire ring only. It might be thought that movable stadia wires, which could be adjusted for any interval, would be preferable, but because of their liability to unexpected changes they are universally condemned.



Graduation of Stadia Rod Used by the U. S. Geological Survey.



Details of Stadia Rod.

Every one who uses the stadia has ideas of his own as to what style of rod is best. The writer believes that no one style of rod is best suited for all classes of work. It is his opinion, however, confirmed by the opinions of not less than a hundred engineers with whom he has discussed the matter, that rods of the simplest designs are best. Such a design is illustrated herewith. For large-scale work with maximum distances of 1,000 ft. smaller subdivisions than tenths may be needed and can be made by alternate white and black (or red) lines on the side opposite the saw-tooth divisions. For maximum distances up to 2,500 ft. a single foot only need be subdivided into tenths, the remainder of the rod being divided into 1-ft. blocks, alternately red and white.

The rods may be home made and should not cost more than about $3 each. The specifications for them are as follows:

To be of clear, straight-grained, well-seasoned white pine 3½ (or 4) ins. wide, ⅞ (or ¾) in. thick and 13.2 ft. long, hinged at the 6.6 ft. mark with two 4-in. strap hinges bolted or riveted in place. A hand-hold strip ⅝ × 3 × 27 ins. bolted to upper end, projects 15 ins. beyond rod when folded. Ends of rod protected with ⅛ × ¾-in. strap iron screwed on.

Paint entire surface of rod with two coats white paint and one coat white enamel paint. Subdivide in tenths, the 5/10-ft. marks made 2½ ins. in height, the tenth marks one-tenth high. The even foot marks and figures to be painted with scarlet vermilion gloss paint; for other marks use enamel black. The figures to be 2½ tenths in height, using V for 5 and X for 10, make the 6 with straight stem, the 9 curved. After the paint has dried, sandpaper lightly, just enough to dull the gloss.

About 5/10-ft. from top attach a piece of thick leather ½ × 2 ins. to keep painted faces from rubbing together when rod is closed. If desired to keep rod open when in use, bolt a plate staple on inside of hand strip near its lower end to project through a slot in rod, a wooden pin through this will hold rod open. Provide a ½-in. strap to hold ends together when rod is closed.

The following modifications in these specifications are suggested as desirable under certain conditions. The hinged joint may be omitted, in which case the rod should be braced by a 2½-in. × ⅞-in. × 6-ft. pine strip screwed on back forming with the rod a T section. This piece may be tapered towards the ends to a width of 1 in. Strips of wood ¼-in. × 1 in. may be nailed to sides of rod so as to project ¼-in. above its face and aid in protecting the graduations from injury. The saw-tooth graduations may be placed on opposite sides of the rod for alternate foot lengths.

For long lines—over half a mile—longer rods with movable targets are often desirable, the targets may be of metal or wood, or even of paper for temporary use. For still longer lines the stadia wires may be revolved so as to permit observing on a horizontal rod, or series of rods. Or a flag-pole may be fixed in the ground while a second is moved into position by signals from the instrument man, the distance between the two rods is then measured with steel tape.

A modification of the stadia method to suit such conditions is occasionally met with which consists of a micrometer eyepiece with a cross wire moved by revolving a screw which has a graduated head. A constant length of rod, a rod with two fixed targets, or two flag poles at a given distance apart are then used. The value of one division of the micrometer head is determined by observing on a rod set at a known distance. The length of the rod for any position may then be found in micrometer division and thus the distance computed with considerable accuracy. This method has been used with great success in carrying on reconnaissance surveys for the government in Alaska and elsewhere.

For careful work it is important that the rod be held vertically when readings are taken. To insure this plumbing levels or a plumb-bob should be provided. A small adjustable circular level on a metal shelf screwed to the back of the rod at a suitable height will be found most convenient. Many rods have been made and used having other units than the foot or meter, the unit being such as to give even distances in feet, meters, or miles, for a particular cross-wire interval. This plan has so many disadvantages that it cannot be recommended for adoption under any circumstances. Rods thus graduated must be used with a certain instrument only and they cannot conveniently be used for leveling.

Probably the most important thing to be considered in stadia work is the value to be adopted for the cross-wire interval. The distance between stadia wires bears the same relation to the focal distance that the rod reading bears to its distance from the instrument (disregarding for the present the constant C). The cross-wire setting for a ratio of 1 unit to 100 or 5 to 500 (the foot being the usual unit in the United States) will, therefore, be 1/100 of the focal distance. It is very important that when the instrument maker computes the intervals for setting the cross wires he focus the telescope for the *average* length of sight and that the interval be made as nearly as possible with the ratio of 1:100.

That which affects most seriously the value of all stadia readings is refraction; irregular refraction; unequal refraction, generally spoken of as "boiling" of the air. This matter was thoroughly investigated by Prof. L. S. Smith of the Univer-

*Geographer, U. S. Geological Survey, Takoma Park, D. C.

sity of Wisconsin, while employed as a transitman on the United States and Mexican boundary survey in 1892-3 and privately in 1894.* Prof. Smith proved conclusively that refraction is one of the greatest causes of error in stadia work, and that the refraction changes appreciably for such slight changes in elevation as that between the two stadia sight lines. Unequal refraction affects the stadia wire value, while "boiling" air affects the legibility of the rod. Since it will generally be impracticable to vary the values adopted for the stadia wire intervals as weather conditions vary, it is essential that their values be determined under average conditions of weather and country, and not, as is so often done, under the most favorable conditions when the air is still.

When a stadia line or traverse is run between two points whose distance apart is known with accuracy from triangulation or otherwise, by comparing the stadia distance, based on an assumed cross-wire value with the true distance, a system of corrections for the stadia distances may be found which when applied to them will give the best results possible. It will seldom occur in actual practice that the true distance between terminal points is known, therefore the following plan is recommended:

On nearly level ground measure a base line not less than 500 ft. in length and preferably as long as the maximum length of sight to be taken later. Taking the center of the instrument as the initial point, mark each 25 ft. for the first 200 ft. and each 50 ft. for the remainder of the line. A stadia value for each point so marked should be determined as follows: hold the rod (always vertically) near the mark and by moving it back and forth, find a point where it appears by stadia measure alone to be at the correct distance. Suppose, for example, the 500-ft. mark is the one under test and that the first stadia reading for it is at a point 2.5 ft. beyond, the correct distance to rod point then is 502.5, record this as one value for the 500-ft. reading. Take several other readings for the same mark preferably under different atmospheric conditions, each time moving the rod an appreciable distance away from its former position before the setting is made. Suppose the mean of all the readings gives 501.5 for the actual value of the distance which by stadia appears to be 500 ft. With this and the values similarly determined for each of the other marks prepare a table such as this:

Stadia reading.	Correction.	Stadia reading.	Correction.
500	+1.5	650	+1.7
550	+1.8	700	+2.5
600	+2.0	etc.	etc.

For any horizontal stadia reading between 500 and 550 for example add about 1.5 to get the true distance. For unimportant sights these small corrections may be neglected and the distance recorded as determined, but to get the *best results obtainable* by the stadia method use corrected distances only; do not attempt to measure any distances greater than the length of the original base line, and do not attempt to carry on work under abnormal weather conditions.

Most text-books on optics or surveying in treating of the stadia apparently try to mystify the student by magnifying the importance of the dreaded constant C and pages are taken in proving that the initial point for stadia distances should not be from the center of the telescope axis, but from a certain distance in front of the telescope. There are good engineers who will say it is never worth while to bother with the constant C, that better results are obtained by neglecting it. Whether they are right or wrong, when the interval is determined by the foregoing method no further thought need be given it.

It is, of course, essential in all stadia work that proper corrections be made for measurements made on slopes.

The Horizontal Distance = Measured Distance × Cos^2 of the vertical angle.

*See report of the Boundary Commissions, Part II, p. 209, Washington Government Printing Office, 1898, also Bulletin of the University of Wisconsin Engineering Series, Vol. I, No. 5, Madison, 1895. Also Engineering News, Vol. Jan.-June, 1895, p. 364.

For angles less than 2° and distances less than 800 ft. this correction will be less than 1 ft. and can in most cases be neglected. For larger angles or greater distances the proper corrections can be computed or taken from tables prepared specially for use in stadia work.

In addition to its usefulness for measuring distances the stadia method is equally useful for determining differences of elevation and for many kinds of work may take the place of the wye level.

In determining elevations, the pointing, when a vertical angle is to be read must always be to the same mark on the rod or else the reading on the rod of the center wire must always be recorded and a height of instrument carried along as in ordinary leveling. The former method is probably the easier. The 4½-ft. mark is often selected as the fixed point and a 2-in. black or red circle painted there to sight to, this being the average height of the telescope above the ground.

Differences of elevation must be computed by this formula:

$$\text{Diff. of elev.} = \frac{\text{observed distance} \times \sin 2\,(\text{vert. angle})}{2}$$

For this computation as well as for the reduction to horizontal, numerous devices have been tried from time to time: diagrams, various forms of slide rules and tables; but for both accuracy and convenience tables are probably the most useful. Until recently the best tables available were those prepared by Arthur Winslow, of the Pennsylvania State Geological Survey. These have been republished in Johnson's Surveying and in a more condensed form in Breed & Hosmer's Surveying. They were computed from the foregoing formulas and give, for each even minute up to 30°, factors which multiplied by the observed distances in hundreds of feet give the horizontal distances and the differences of elevation.

Tables prepared by Arthur P. Davis, M. Am. Soc. C. E., give the differences of elevation for even minutes for each even hundred feet from 100 to 900 up to 8° and for each five minutes to 20°, so that elevations desired can be computed from the selected tabular values by addition. Recently the U. S. Geological Survey has published similar tables prepared by C. G. Anderson giving differences of elevation for each minute up to 6° for distances up to 3,500 ft., and for distances of 1,100 ft. up to 17°. The desired results can be obtained from these very readily by addition.

When the differences of elevation are less than the length of the stadia rod it may be used as in ordinary leveling, reading on it for back or foresights. When the differences of elevation are but little more than the length of the rod, the "stepping method" of determining them may be employed; this is best described by an example.

Suppose the stadia reading gives the distance as 640 ft. (the stadia interval being 1:100) then the stadia wires cover 6.4 ft. on the rod. If when the telescope is leveled the line of sight falls below the rod, note carefully some spot or mark on the ground cut by the central horizontal wire, quickly move the lower stadia wire up to that mark by means of the tangent screw. If now the rod is in view, read the point where the upper cross wire strikes the rod, say it is 2.6 ft. Then the foot of the rod is 6.4 — 2.6 = 3.8 ft. above the horizontal line through the instrument; or if need be move the cross wires a second or third time up through the 6.4 ft. interval. Multiply the 6.4 by the number of moves, subtract the final reading on the rod and add the height of instrument above ground, for the difference of elevation.

When the horizontal line falls above the rod it is not always possible to find reference points for the cross wires but often a point on a distant hill, a leaf or limb of a tree, or even in some cases a well defined point on a cloud may be used. This method when applicable will afford quite a saving in time.

In Engineering News for Oct. 21, 1909, there was an excellent article on Stadia Surveying by Mr. Arthur W. Tidd, giving many valuable suggestions in regard to the general planning of stadia work which the present writer can heartily commend. The only criticism of the methods therein outlined which the writer cares to offer is to suggest that for work such as that described it would seem that the plane-table might have been used with great advantage.

For general map work on any scale larger than 1 mile to 1 in., and for certain kinds of mapping on smaller scales, the plane-table and the stadia are in the opinion of the writer unequaled by any other instruments yet devised. A rough estimate of the number of miles of stadia distances measured by the Coast and Geodetic Survey, the U. S. Geological Survey, the Lake Survey and other United States surveying organizations would be considerably more than 200,000, and it is safe to say that for more than nine-tenths of the work the plane-table was used.

In using the stadia it is customary to set one wire on an even foot mark, then to read the fraction on the other. For long distances the middle wire may be taken with either of the others and the rod reading thus obtained doubled in order to get the distance. For important sights always repeat the rod reading. Stadia lines should always be run in circuits or else commenced and ended on points of known position and elevation.

A summary of the principal items to have in mind for careful stadia work is here given.

Use rods of the simplest designs graduated into regular units, and when in use always hold them vertically.

Determine the value of the stadia interval for each instrument used under *average* conditions, never accepting the maker's statement alone as to its value.

Correct for all inclined sights when the amount is appreciable, using corrections computed by the stadia formulas only.

Sight a fixed point on the rod for differences of elevation or else read and record the point actually cut by the horizontal wire, take great care in recording the proper signs (+ or —) for vertical angles.

Test the adjustment of the line of collimation and of the level daily.

If a plane-table is used, distances and elevations should be immediately computed and plotted and no other than the rough temporary notes need be kept.

Notes On Some European Testing Laboratories.*

[CONTRIBUTED.]

This account is based upon inspection of the laboratories of the technical high schools at Zurich, Stuttgart, Munich, Dresden, and the laboratory at Gros-Lichterfelde, near Berlin, which was formerly at the technical high school at Charlottenberg. This union of testing laboratories and technical high schools is common in Germany, and the prominent and advanced laboratories are so situated. The technical high schools are supported by the state, and in educational rank they correspond to our engineering schools, such as those at the universities of Illinois, Wisconsin, Cornell, Purdue, etc. The instruction, however, is of a more advanced grade. A student can obtain his doctorate in these schools. They are of much higher rank than the high school in our understanding of that term. The features which distinguish these laboratories may be summed up as follows:

(1) The highly specialized equipment, in which each machine is designed for a special test.

(2) The use of hydraulic cylinders and pistons in loading elements of the testing machines, and the central pressure plant serving the various machines of the laboratory. This produces a quiet and agreeable atmosphere.

(3) The delicacy and finish to all machines.

(4) The thoroughness and care with which all observations are made, and the absence of haste.

*This article is compiled from notes made by an engineer for his personal use, during a visit to Europe last year.

(5) Quite generally the commodious and well-designed buildings for these laboratories, and excellent technical staff. One is impressed, also, in the case of Dresden and Stuttgart, with the practical investigations on a very large scale, because it is sometimes thought that the German spends too much time on very minor and remote problems. At Stuttgart the experiments of Bach on the strength of large flat plates are extensive and practical, on full-sized scale, conducted on a machine specially built for the purpose. Again at Dresden the strength of reinforced-concrete beams, under long continued and repetitive loads, was under investigation. The scope of the experiments and the size and great number of specimens were remarkable.

(6) There was also an apparent leisure in publication and an absence of the feeling which obtains in this country that the results of experiments must be published rapidly in order to preserve public interest.

(7) The work of instruction of students appears to absorb a much smaller portion of the activities of the organization than is the case in the United States, where the testing laboratories of the universities are over-burdened with the instruction of students and where the organization usually does not provide for the necessary mechanics, assistants and professors required for investigative work.

ZURICH.—The Zurich Polytechnicum was developed by Tetmajer, and is now in charge of Prof. Schule, and has long enjoyed the reputation of a fruitful field of practical and scientific research. It is located in a special building and possesses the standard testing machines, mainly those constructed by Amsler of Schaffhausen. These machines are in quite general use and are characterized by the use of a floating piston, that is to say a piston which is very carefully machined to a close fit in its cylinder. There is no packing, and heavy cylinder oil (usually castor oil) is used, friction being thus avoided. The indication of the cylinder pressure is the true load on a specimen. The machines at Zurich, and the laboratory in general, are perhaps behind the newer laboratories at Stuttgart and Dresden. A very important research upon the clays of Switzerland has been just completed. The excellent work shops and technical staff characterizing German laboratories were a feature of the Zurich laboratory.

STUTTGART.—The laboratory of the technical high school has recently been removed to larger and new quarters on the outskirts of the city. The famous Prof. C. Bach, who is in charge of this laboratory, is a world-wide authority on the strength and elastic properties of materials of construction. The publications of this laboratory appear in the "Zeitschift des Vereines Deutscher Ingenieure." Some 88 titles of articles proceeding from the laboratory are on record. The plant comprises an engine and power laboratory and a material testing laboratory.

The testing laboratories comprise a three-story structure with offices, drafting rooms, and rooms on the ground floor for cement work, and two adjoining one-story additions containing the testing machines and work shop. The equipment is of the finest character and with all modern improvements. As usual the machines are hydraulic, one of them being of the capacity of over 1,000,000 lbs., and free height of nearly 30 ft. This consists of a cylinder and floating piston (made by Amsler), and two uprights not threaded, but shouldered for adjusting the straining head at different heights. The crosshead is not braced laterally as is the case in large testing machines in America.

The cement equipment of the German laboratories is standard. It is notable that, contrary to American practice, all the sifting and mixing and tamping of specimens is by machinery and not by hand. At Stuttgart interesting tests were under way on the strength of steel plates supported around the periphery and subjected to hydraulic loads, a continuation of the work which Prof. Bach has been carrying on for years; also a new material under test for us at Messina, (Sicily), reinforced in the case of beams with a wooden tension member. This is reported to have a large degree of elasticity and strength and to be fireproof.

MUNICH.—The laboratory of the technical high school in Munich is old but is interesting as being the former laboratory of the late J. Bauschinger. The machines upon which he made his tests of metals under repetitive stress are still in the laboratory. The present head of the laboratory is Prof. Foppl, a renowned writer upon mechanics. The large testing machines have packed pistons but are calibrated from time to time with standard bars; the smaller machines are calibrated by means of a steel ring, the diametral deformations of which are indicated by means of an internal lever and scale. There is a special lever machine for examining these rings from time to time. It is to be noted that the high school at Munich and the laboratories are to be reconstructed at an early date at a cost of approximately $1,000,000, and are expected to be occupied in October, 1910.

J. AMSLER-LAFFON & SON.—On the way to Stuttgart from Zurich, a visit was made to the testing machine works of this company at Schaffhausen. These testing machines are standard throughout Europe, especially the small size compression machine whose loading element is an unpacked, freely moving piston in a hydraulic cylinder. Amsler's latest load-measuring device is a pendulum actuated by the pressure of the oil in the cylinder. The price for a 60-ton compression machine with capacity for a 20-ton bending experiment is $680. This includes the testing machine, the pendulum, manometer and autographic recording apparatus. The workmanship on Amsler's machine is unusually excellent. His pistons and cylinders must be well made and of good hard steel to work properly with the close fit required in the case of the unpacked pistons. On account of the great expense in constructing a large piston in his ordinary system, he has designed a large testing machine of 1,000,000 lbs. capacity with packed pistons. In this case the load on the machine is measured by means of the elongation of a definite length of the lower end of the columns. This elongation changes the volume of a pressure chamber and pushes out the fluid to the recording gage. In some of Amsler's smaller machines, the load is measured by means of a spring constructed of two parallel bars of spring steel separated some three or four inches, the load being carried at the center.

TECHNICAL HIGH SCHOOL AT DRESDEN.—The testing laboratory has been removed and rebuilt at the outskirts of the city, occupying a three-story building with testing laboratories in the basement and in a large wing. The laboratories are well equipped with the newest improvements and a proper technical staff with suitable quarters. The equipment for metallography and photography is to be noted. The largest machine is a thousand metric ton press (about 2,200,000 lbs.) with capacity for length of specimen of 14.76 ft. This is a hydraulic machine with two columns. The testing machines are served by an accumulator. The work carried on includes testing of metals, building materials, lubricating oils, investigations in technical chemistry, metallography, and tests on machines. Of special interest in this laboratory were the experiments on reinforced-concrete beams and slabs submitted to periodic and to constant loads, representing experiments on a practical scale and of extraordinary extent.

TESTING LABORATORY AT BERLIN.—The Royal Testing Station of the technical high-school at Berlin, recently moved to Gros-Lichterfelde West, consists of two long testing halls connected with a central three-story structure. There are also special buildings for fire tests and impact tests, and for the work shops. This laboratory has been elaborately described in a publication entitled "Das Konigliche Materialprufungsamt der Technischen Hochschule, Berlin," a volume of some 383 pages published by Julius Springer, Berlin, 1904. This is the largest testing laboratory in Germany, and so far as the writer knows, in the world, with a force, he is told, of some 250 persons. It is under the direction of Prof. A. Martens. The cubic space is over 65,000 cubic meters. The departments include metal testing, building material testing, metallography, chemistry, paper testing and oil testing.

In visiting the laboratory one is impressed by the large organization designed to push through a large amount of routine testing. It seemed to me, however, that the laboratories at Stuttgart and at Dresden are in advance of the Berlin laboratory in their special departments, and showed greater evidence of a research spirit.

The testing machines were mainly those of Pohlmeyer. In the case of the large machines the pistons are packed and the friction, which is obtained by moving the piston when free, is stated to be from 3 to 5%. Autographic diagrams are used very largely. An interesting apparatus for testing railway ballast may be mentioned, and also the use of the sand blast for determining the hardness of brittle materials. In brick tests, the two halves of the brick are placed one upon the other and connected by mortar or plaster of paris. There is a large laboratory devoted to the examination and tests of papers. This includes an analysis of the fiber and the testing of the strength, for which latter purpose there are some half dozen Shopper vibratory machines and also tension machines of the pendulum type. All these machines are operated by water pressure from the central accumulator. There is also provision for the making of experimental paper from the various materials.

A 24-MILE STEEL PIPE-LINE for the city of Portland, Ore., is to be built, parallel for the most part with the present Bull Run conduit (see Eng. News, Feb. 6, 1908). From the head-works to a place called Lusteds, ten miles, the new line will be 52 ins. in diameter, while from Lusteds to Mt. Tabor, where the line will connect with two new reservoirs under construction on the eastern border of the city, its diameter will be 44 ins. The capacity of the conduit is estimated at 45,000,000 gals. per day, or double that of the present conduit. Of the two reservoirs under construction, one is to have a capacity of 50,000,000 gals., at Elev. 411.6, and will be connected with high service; the other reservoir, at Elev. 305, connected with the intermediate service, will have a capacity of 75,000,000 gals. These reservoirs are under contract to be completed during 1910. The contract for the pipe-line, which has recently been awarded to the Schaw-Batcher Co., of Sacramento, Cal., calls for completion on June 15, 1911. Specifications for the pipe-line call for thicknesses of ¼ to 7/16-in., for double-riveted straight seams and single-riveted circular seams, for taper joints, and for coating as follows:

After the above described cleaning and inspection, which must be done under cover, every pipe shall be coated with "Mineral Rubber Coating," or such other material equal thereto in all its qualities, as hereinafter specified.

The coating must be free from blisters and bubbles, and must not be affected by exposure nor by the action of the soil or salt water. It must strongly adhere to the pipe under all circumstances, and must not become soft enough to flow at a temperature of 150° F., nor brittle enough to crack or scale off at freezing temperature.

The pipes before being dipped must be clean and free from rust, and no pipe shall be coated unless examined and approved by the inspector immediately before the process of coating begins. They shall be dipped in a bath of the "Mineral Rubber Coating," heated to 400° F., or more, and shall receive a uniform coating not less than 1/16-in. in thickness. While in the bath the pipe shall be so manipulated, scraped, brushed and redipped, if necessary, in accordance with the directions of the inspector, as to give a sound and perfect coating. After the pipes have been removed from the dipping tank they shall be set vertically while cooling. Proper facilities for handling the pipes and allowing all surplus material to drip off shall be provided by the contractor. The cost of all labor and material involved in the coating of the pipes must be included in the price bid for furnishing and laying said pipes.

The materials for the mixture, the appliances and method of boiling, melting or applying and testing the coating, shall be subject to the approval of the engineer or his authorized inspector. In case that from any cause the coating on any length may be found to be defective, it must be removed, and should the defect be from brittleness or scaling, or improper composition or application of the coating, it must be scraped off entirely, outside and inside, and another coating applied.

Mr. Joseph Simon is Mayor of Portland and Chairman of the Water Board. Mr. Frank T. Dodge is Superintendent and Mr. D. D. Clarke, M. Am. Soc. C. E., is Engineer of the Water Board. We are informed by the latter that he understands that the contractors have arranged with the East Jersey Pipe Co. to furnish lock-bar pipe for the work. Tabulated bids for this pipe-line contract were published in Engineering News of March 24, 1910.

The New Dock Facilities at Avonmouth, England.

The continually increasing extent and importance of the shipping trade of Great Britain makes necessary the frequent provision of more extensive facilities to accommodate the increasing traffic and the increasing size of steamships. Under these conditions the various ports are all the time carrying out improvements and extensions, and owing to the great tidal range a large amount of the work consists in providing new docks to receive the vessels. An interesting example of work of this kind is afforded by the recent improvements at Avonmouth, on the Bristol Channel, which is part of the port of Bristol.

The city of Bristol is seven miles from the Bristol Channel (an arm of the Atlantic extending up to the river Severn), and is on the river Avon. This is a winding stream with a tidal range of 31½ ft. at the city docks, and 42 ft. at the mouth. While it has been dredged to give a depth of 35 ft. at high water of spring tides, it is little more than a mud bank at each low tide. The city has been an important port for hundreds of years, and early in the 19th century it converted a part of the river which passed through the city into a harbor by means of locks, a new channel being made for the river. With the growth of the size of vessels, the disadvantages of the city as a port became very apparent, and for the past fifty years numerous projects have been proposed. One of the most comprehensive was the construction of a dam and lock near the mouth of the river, to form a great harbor. This was on the line of the older work which created a harbor in the city, and in all probability would have been the best solution of the problem. But the city authorities were afraid of such an extensive work, and though it was proposed many times it was never adopted.

While the city was deliberating over the problem, two private companies established docks at the mouth of the river; one at Avonmouth (with 19 acres of water area), on the east side, and the other at Portishead (12 acres), on the west side. Both of these places have railway communication with the city. These docks were opened in 1877 and 1879 respectively. The former was the larger and more important, and at once began to attract shipping which had formerly gone up the river to the city docks. In 1884, the city purchased both the private dock enterprises, and has since carried out extensive improvements in warehouse and railway facilities. These improvements were made not only on account of traffic requirements, but to attract additional traffic and also to meet the competition of other ports on the Bristol Channel. The city now owns 250 acres at Avonmouth, including a large area of reclaimed land.

In 1901, the city obtained authority to build an additional dock at Avonmouth. Work on this was commenced in March, 1902, and the dock was opened in July, 1908. The general arrangement is shown in Fig. 1, and the dimensions of the two docks are as follows:

	Old dock	New dock.
Water area	19 acres	30 acres
Dock wall frontage	4,800 ft.	11,000 ft.
Dock, length	2,180 "	1,120 "
Dock, width	500 "	1,100 "
Entrance lock, length	485 "	875 "
Entrance lock, width	70 "	100 "
Depth over sill, H. W. spring tides	38 "	46 "
Depth over sill, H. W. neap tides	28 "	36 "

The new dock (known as the Royal Edward Dock) is approximately rectangular. From one side extends an arm 300 ft. wide and 1,800 ft. long, which is used at present as a timber dock. A similar arm (on the same side) will be built when additional area is required. At the inner end of the dock is an arm 500 × 250 ft. extending towards the old dock, and connected with the latter by a channel 85 ft. wide and 525 ft. long. This channel is closed normally by a sliding caisson gate, and is spanned by a railway swing bridge. Parallel with the entrance lock, and opening from the dock is a dry dock 875 × 126 ft., with an entrance 100 ft. wide. The normal depth of water is 34 ft., but can be increased to 36 ft. by pumping. The dry dock can be pumped out in two hours, but at low tide the emptying is facilitated by a 6-ft. gravity discharge culvert. The dry dock is of concrete, faced with stone.

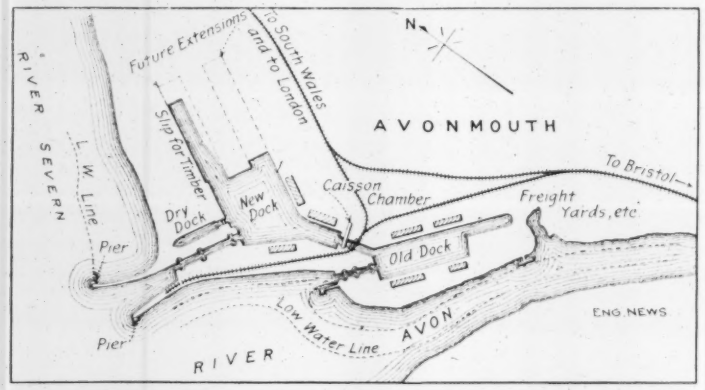


FIG. 1. PLAN OF THE DOCKS AT AVONMOUTH, ENGLAND.

The dock walls (Fig. 3) are of concrete with a granite coping 10.3 ft. above normal water level and a corbel course of hard freestone 14 ft. below the coping. Between these stone courses the wall has an 18-in. facing of hard blue brick. The foundations were carried down in open braced trenches through silt, sand and gravel, to a bed of hard red marl, at a level of 78 ft. to 83 ft. below the coping. The walls are 30 ft. wide at the base, and 21 ft. at the level of the dock floor, to which they are connected by a toe curve. The upper part of the wall has the back formed in offsets, giving a top width of 13 ft. A subway for pipes is formed in the top of the wall. The lock is also of concrete, and its walls and culverts are faced with blue brick.

After the completion of the dock walls, the enclosed area was excavated to the desired level for the concrete floor. In order to avoid any liability of the water from the old dock breaking through along the channel connecting it with the new dock, this channel was not excavated until the walls and gate chamber at its connection with the new dock had been completed, and the steel caisson gate placed in position across the channel.

The lock (875 ft. long) has three sets of gates, 300 ft. and 575 ft. apart. The gates are of steel frame construction, but with wrought iron skin plating. This plating extends nearly to the top of the gate, and that of the outer side of the gate is projected by a sheathing of creosoted timber. The gates are of great size and weight, the width of the lock being 100 ft. and the depth from coping to roller path 56 ft. 4 ins. The depth of the sill is 54 ft. 4 ins., due to the great range of tide at this port, giving a maximum head of about 45 ft. of water against the outer gates. The gates have the skin plating carried to a height of 51½ ft. above the roller path. Each leaf weighs about 250 gross tons. The above particulars apply to the outer and middle gates. The inner gates are 6 ft. less in height.

The miter posts and the closing pieces at the bottom are of greenheart timber. Each leaf has hydraulic ejectors for draining the air chambers, the connections enabling each compartment or chamber to be drained separately. To each gate is attached one end of an operating lever (above the level of the skin plating), the other end of the lever being pivoted to an anchor block. The connecting rod of the horizontal hydraulic cylinder which operates the gate is attached to the lever, the other end being attached to the cross-head on the piston rod. By this arrangement the stroke of the piston is reduced to 12 ft. 9 ins. An interesting feature is that the gates are protected by heavy boom chains which are suspended across the lock when the gates are closed, but are lowered so as to rest upon the floor when the gates are open. They are operated by hydraulic hoists. A ship striking the chain would encounter the drag due to taking up slack (the chain hanging in loops in the side chambers), so that its force would be largely absorbed in this way before the chain became taut.

A sliding caisson gate is used for closing the 85-ft. channel connecting with the old lock, the gate being hauled back into a chamber when the channel is to be opened. The caisson is 87 ft. 3 ins. long on top and 81 ft. on the bottom, 14 ft. 3 ins. wide, and 37 ft. 3 ins. high. Its section is shown in Fig. 2. The air or water-ballast chamber is 17 ft. high, and extends the full length and width of the caisson, but is divided into four compartments by vertical watertight bulkheads. As in the lock gates, the framing is of steel, and the plating of wrought iron. There are three plated or solid decks and six decks formed by the horizontal bracing. The weight is 570 tons, including cast-iron ballast. The gate is operated by wire cables from two hydraulic cylinders placed side by side, and working under 750 lbs. pressure. The plungers work in opposite directions and the pulleys give a multiplying ratio of 8 to 1. The gate travels at a speed of 66 ft. per min.

A floating caisson (Fig. 4) is used to close the entrance to the dry dock, and when not in use is moored in the dock. It is 104 ft. long, 20 ft. wide at the bottom and 14 ft. on top. It has a height of 53 ft. with an air chamber 27 ft. high. The floating weight is 1,580 tons. The caisson is divided by two transverse bulkheads. It has ten decks, of which seven are bracing only, and three (Nos. 1, 3 and 5) have solid deck plating. In the middle compartment are two 15-in. centrifugal pumps, placed horizontally, and each

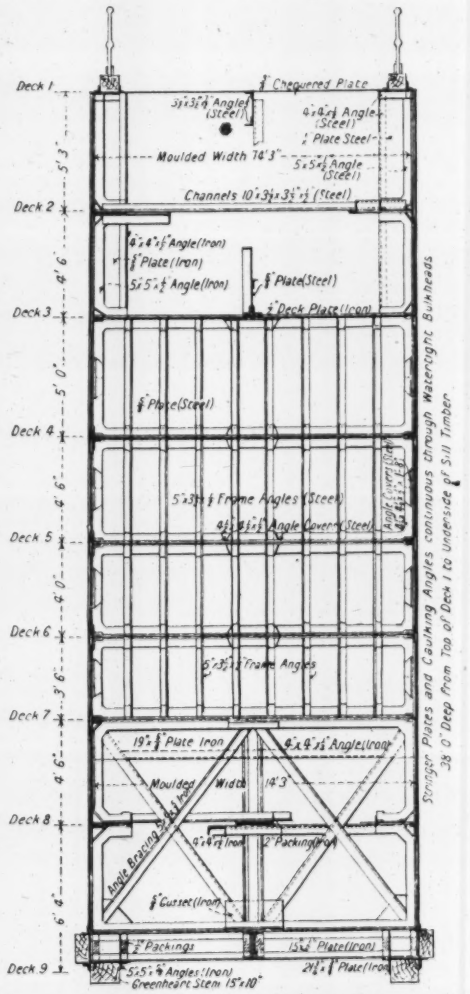


Fig. 2. Section of Rolling Caisson Gate for the Channel Connecting the Two Docks at Avonmouth, England.

driven by an 80-HP. motor on the vertical shaft. These motors are placed in a well or compartment which extends to the second plated deck (No. 5). This caisson can be placed at the entrance lock to enable the water to be pumped out during inspection or repair of the gates.

The entrance to the lock is flanked by two jetties or piers faced with concrete walls. The north pier is 1,200 ft. long and the south pier 900 ft. They are 250 ft. apart at the inner or lock end and 700 ft. at the outer or channel end. The south pier has on the inner side a timber structure with landings and stairways so that passengers may be landed here at various stages of the tide.

The foundation for each wall is a row of monolithic concrete blocks, 30 × 25 ft. in plan. These were built in place on steel shoes, the forms being carried up and the concrete placed as the weight sunk the structure into the mud and gravel. Each block had four wells 6½ × 8½ ft., through which the material was excavated by grab buckets, hydraulic jets being used to loosen the material. When the shoe reached rock, the wells were cleaned out and filled with concrete. The blocks were 5 ft. apart, and these spaces were closed by plank forms, so that the material could be removed and concrete filled in. The maximum height of the blocks was 60 ft.; and the height from foundation to top of wall is from 77 ft. to 83 ft. The monolithic upper walls were then built in place, the two walls of the pier being tied together by 10-in. steel I-beams. The head of each pier is a monolithic block 55½ ft. diameter. On these pier heads are the two light-houses, 41½ and 21½ ft. high respectively.

Power for the hydraulic machinery is furnished by the power plant of the older dock, which has been supplemented by an additional accumulator. A new pumping station serves the new dock and its adjacent dry dock. The main plant consists of three vertical compound engines of 850 HP. each, directly connected to three centrifugal pumps having impellers 7 ft. 3 ins. diameter. Each pump has two 38½-in. suction pipes and a 54-in. discharge pipe. On each 54-in. discharge conduit is a 54-in. sluice valve operated by hydraulic power. A small engine operates the air and circulating pumps. There are two 12-in. drainage pumps, one operated by a compound engine and the other by an electric motor. Steam is supplied by two Lancashire boilers 30 × 8½ ft. (with superheaters and economizers), and two water-tube boilers. Induced-draft avoids the necessity of a tall chimney.

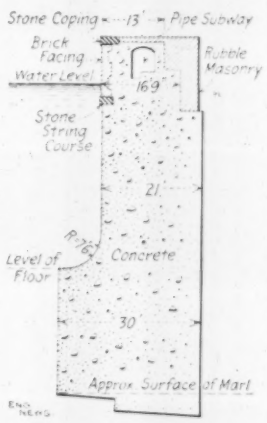


Fig. 3. Section of the Wall of the New Dock at Avonmouth, England.

On each side of the dock are freight sheds, 500 × 157 ft. and 450 × 130 ft. The inbound or import sheds have reinforced-concrete columns, girders, floors and roofs, with concrete pile foundations. The walls are of galvanized iron, with sliding doors in each panel of the front and back. One side of the shed is 16 ft. from the dock wall, and the floor slopes up from the ground level at this side to the level of a platform serving a double track railway which passes through the rear side of the shed. The columns are spaced 24 ft. and 25 ft. apart. These sheds are two stories high, and have the front portion of the roof formed to support tracks for traveling jib cranes of 1½ tons capacity; this part of the roof also has hatchways through which the cranes can hoist and lower their loads. In this way the cargoes can be transferred directly between ships and warehouses without interfering with traffic on the space between the dock and warehouse. The outbound or export sheds have only one story and are of steel frame construction, with timber piles and galvanized corrugated steel sheeting.

There is a nine-story grain elevator, 72 × 222 ft., 89 ft. high. This is of reinforced-concrete construction, with concrete piles. The bins are 11¾ × 10 ft., 50 ft. deep. It is served by railway sidings, and electric capstans are provided for handling the cars. Chutes and spouts deliver grain (in sacks or in bulk) to coasting vessels. The conveyor belts which carry the grain from the importing steamers to the elevator run in a concrete subway or tunnel. Pneumatic elevators raise the grain from the ship's hold and discharge it into cars or upon the conveyor belts.

The design and execution of the work were under the direction of Mr. W. W. Squire, M. Inst. C. E., Chief Engineer of the Docks Department of the city. Sir John Wolfe Barry, M. Inst. C. E., was Consulting Engineer. The contractors were John Aird & Co., of London.

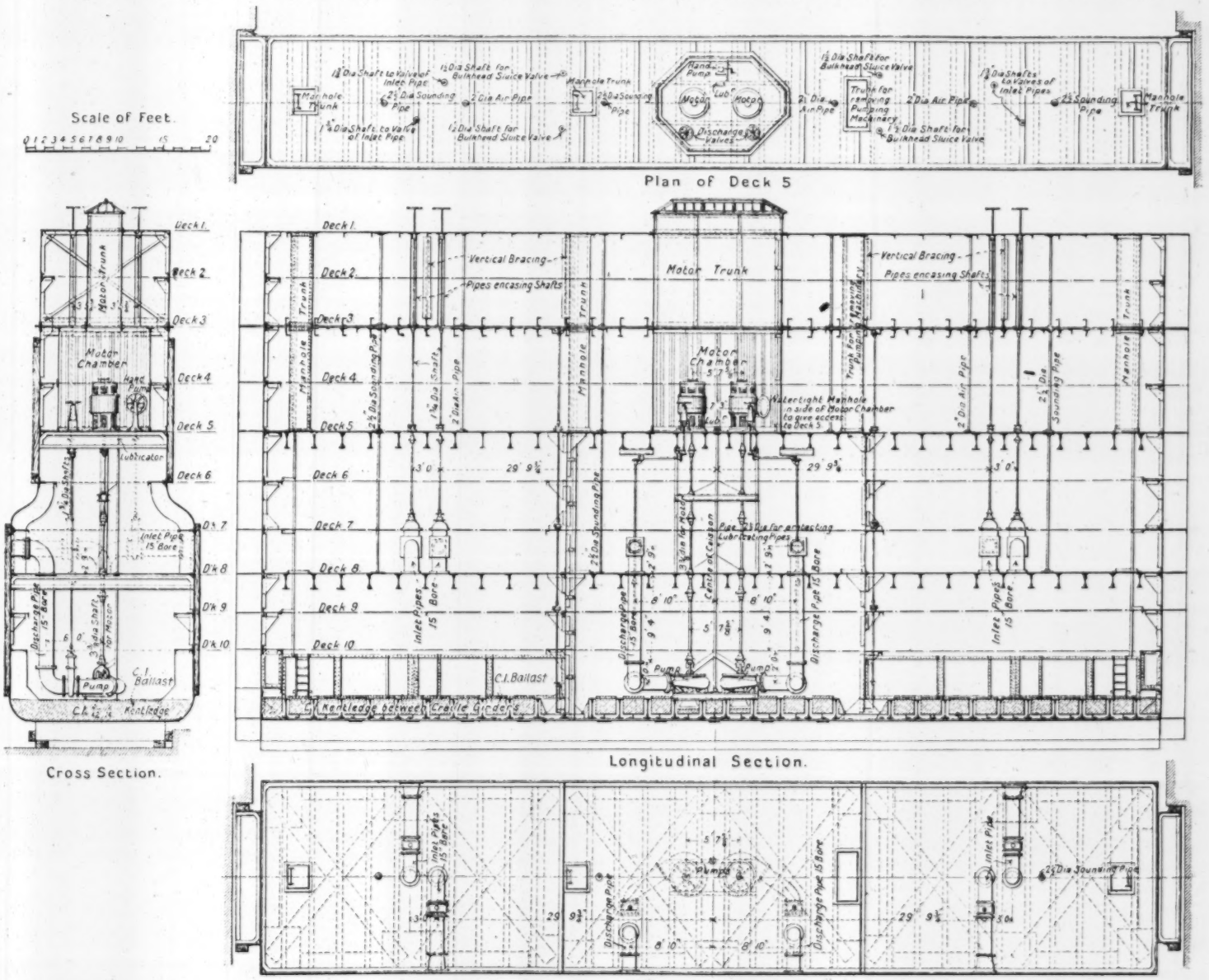


FIG. 4. FLOATING CAISSON FOR THE ENTRANCE TO THE DRY DOCK AT AVONMOUTH, ENGLAND.

The Production and Utilization of Ozone With Especial Reference to Water Purification.

Early Development.

The use of ozone as a purifying agent has received such varied publicity that the history of the discovery and development of the gas needs but brief attention in an article on present processes, though a brief summary of progress is needed to show the relations between these processes.

A Dutch physicist, Van Marum, in 1783, while studying the behavior of gases in the path of electrical discharges, noted that oxygen gave a decided odor. But not until 1840 was this peculiar form of oxygen recognized as a distinct gas. In that year Friedrich Schonbein, a German chemist and professor at the University of Basel, Switzerland, showed that oxygen, after being subjected to electrical stress, possessed peculiar chemical properties. For instance, it liberated iodine from potassium iodide. To this gas he gave the name "ozone."

The gas remained more or less of a scientific curiosity for a number of years, and the study of its properties seems not to have been attempted for practical ends until Berthelot took it up in 1890. He was followed by a long line of experimenters, most of them Europeans.

Only a few of the army of experimenters made definite contributions to the advancement of the art of producing ozone in large quantities on a commercial scale and with a minimum expenditure of power.

Ozone is formed during a wide variety of chemical and physical actions. It has been reported produced (1) at the positive pole in the electrolysis of some liquids such as water and sulphuric acid. (2) by the slow oxidation of phosphorous in air, (3) by the slow evaporation of water from large areas, (4) by the action of fluorine compounds, particularly by the addition of fluorine to water, (5) by sudden transitions of air or oxygen from extreme heat to cold, (6) by the oxidation of essential oils like turpentine, (7) by the influence of electrical stress, and (8) by the action of radiations or emanations from radio-active salts.

Ozone is generally believed to exist normally in the atmosphere at different places under fairly well defined conditions—for instance in regions well forested, at water surfaces where there is marked evaporation, and where silent discharges of atmospheric electricity must go on over large areas of the earth's surface with the various atmospheric changes. Some even go so far as to claim that it is nature's own disinfectant and deodorizer.

In early experiments it became evident that traces of ozone could be produced by comparatively low electrical potentials but that its production in quantity, or with any approach toward fair efficiency, required high-tension discharges.

It scarcely needs to be said that to-day all the commercial processes for the production of ozone employ electrical discharges at high tension. At first its production in anything like useful amounts was possible only with cumbersome static electrical machines or induction coils operated by primary batteries.

Discharges embodying any large amounts of energy without bulky expensive and dangerous aggregations of apparatus have been made possible only since the development of modern electric machinery and, particularly, the alternating-current generator and high-tension transformer.

There are several conditions, under which oxygen or air is subjected to electric stress or discharge, which influence the quantities of ozone produced for a given input power. (1) Prof. Arrhenius, judging from many experiments, states that the presence of very small quantities of water vapor favors the production of ozone, while (2) considerable quantities of carbon dioxide have a reverse effect. It is generally believed to be necessary to limit the amount of water vapor present to very small quantities to secure high efficiency and to prevent the production of hydrogen peroxide and various nitrogen compounds. In the early experiments, air to be ozonized was dried with some not too hygroscopic substance like sulphuric acid or lime. To-day the tendency is to rid the air of excess moisture by refrigeration. (3) Low temperatures of the air or oxygen to be ozonized are favorable because the stability of ozone increases with decreasing temperature. (4) The air should be free from dust as some ozone is lost in oxidizing this. (5) Since ozone occupies but two-thirds the volume of the oxygen from which it is formed, an increase in pressure is also favorable to efficient production. (6) The presence of chlorine or nitrous oxides hinders the formation probably through the change of the equilibrium and saturation points of air for ozone. (7) Hydrogen promotes the yield if the formation of water is rigidly avoided, and (8) it has been found that silicon fluoride greatly assists the production of ozone.

The formation of ozone from oxygen is an endothermic process—heat is absorbed. This fact does much to explain the formation and behavior of the gas. From data reported by various authorities, from 1,275 to 1,380 grams would be produced per KW.-hr. actually absorbed by the chemical change from O_2 to O_3. The efficiencies

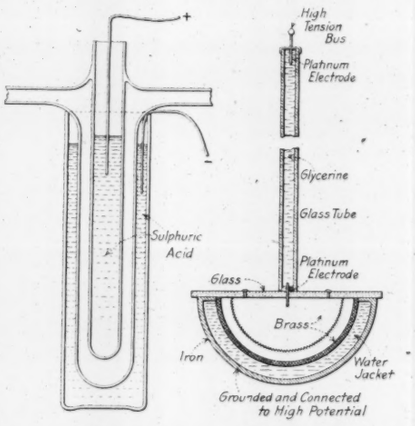


Fig. 1. Berthelot's Ozone Generator. Fig. 2. Schneller's Ozone Generator.

of ozone production, shown later in this article, are of about the magnitude of those prevailing in the production of light from electricity.

Explanations of the formation of ozone have been numerous and ingenious. That most generally accepted at present is based on molecular motion and has perhaps been best stated by Dr. C. P. Steinmetz in his numerous lectures on the effect of ether radiations. This theory regards the chemical effects of all ether radiations—recognized by light, heat or electrical waves—as more or less specific, for various compounds, to definite frequencies of the ether movement, setting up resonance effects upon the natural molecular or atomic motion. Thus if compounds of the heavy silver atom (atomic weight 108) are broken down by light rays close to the upper limit of the visible spectrum, then the lighter oxygen atom would be expected to be influenced by higher frequencies far beyond the visible range—by ultra-violet radiations such as accompany electrical discharges.

Commercial Uses of Ozone.

The very low concentration at which ozone was produced in all the earlier apparatuses, was alone sufficient to prevent any practical utilization of the gas. Berthelot, who designed the ozone generator which is the prototype of much apparatus in use to-day (see Fig. 1), secured a concentration of only about 0.05 gram per cu. meter of air, while to-day as high a concentration as 30 grams per cu. meter can be produced with several generators in series and working at very low efficiencies.

The utility of ozone as a bactericide through its marked oxidizing properties, was pointed out by de Meritens in 1886 and Frolich about 1890.

To-day there is little question of the efficacy of ozone as a commercial chemical and sterilizing agent but there are questions of practicability, related mostly to the cost of production and utilization, and to the ease of maintenance of generating apparatus. By the improvement and refinement of the generators, the cost of production has become a small part of the cost of any complete process for using ozone for purifying or bleaching. This condition arises largely through the expense of forcing contact between the ozonized air and the material to be treated.

The process about which most interest centers, naturally, is the purification of water. There are elements in the proposition to kill all bacteria and to get rid of organic contamination by introducing "electrified air" that appeal to the popular imagination as no proposal to filter or chemically sterilize water can. It has been demonstrated that ozone is a simple and effective sterilizing agent and leaves no residue in the water repugnant to the public mind as use of chemicals would. Whether or not an ozone plant is the best thing for a given location often simmers down to a question of the costs, and these depend to a very large extent on local conditions so that results obtained in one place are to be applied with caution to another place and only under the advice of competent engineers. Further statement of this particular problem would be out of place here in an article showing the development and operation of systems now being exploited with promise of future usefulness.

The use of ozone for dry sterilization, as of air, has been studied in the laboratory and, to a limited extent, has been commercially applied. In some experiments conducted by an independent American laboratory for one of the manufacturing companies, a 15-minute exposure of colon threads to ozone in a closed box was sufficient to sterilize only four out of ten. A three-hour exposure in an ordinary room, with cracks unstopped, into which ozone and air at a concentration of about 8 grams per cu. meter of air, was blown, was sufficient to sterilize all threads exposed in the room. Experiments conducted in a dry-disinfecting plant in this country leave no doubt as to the effectiveness of ozone as a disinfectant, but as yet the system has not found extensive application.

A large plant, on the Gerard process, has been in operation at the Pittsburg Homeopathic Hospital for many months, purifying water for use in the hospital and supplying ozone for various medicinal and surgical uses. The ozone is used for sterilizing instruments, bandages, etc., and for dressing wounds and ulcers. Experiments made here, with very low concentrations of ozone in the ward atmosphere, have shown a beneficial physiological action—making patients cheerful, stimulating appetites and assisting toward sound sleep. By other observers the therapeutic action has been likened to the exhilaration of brisk exercise in dry cold air and sunshine.

As ozone is a deodorizer as well as a disinfectant, its use as an adjunct to the ventilation of auditoriums, restaurants and the like, has been proposed. Indeed small ozone-making sets are now manufactured for such uses.

Air charged with ozone has been proposed for the auxiliary treatment of cold-storage goods, to decrease the amount of refrigeration by which preservation is assured. Such assistance by ozone is possible, of course, only where the propagation of the organisms producing decay begins at the surface or where they can enter from the surface.

The industrial possibilities of the use of ozone seem limitless. In brewing establishments it provides an easy way of sterilizing vaults, casks, and perhaps the product itself. In distilling, it has given partial success in the rapid aging of liquors and doubtless improvement is possible. Oils, greases, sugars, flours, starches and other edible products should be safely bleached. Textiles, feathers, etc., may be bleached, but at present it is unquestionably more expensive than to use other methods now common, such as with calcium hypochlorite. At the same time there may be some advantage in the resultant mechanical condition of the goods after treatment. It has not yet been openly demonstrated which

of these processes are completely and commercially feasible.

The number of ozone generators that have been designed and patented is almost innumerable. Few of them have ever been given a practical trial, and a still smaller number survive in the commercial systems which are now being exploited by a few well known companies. The names connected with these few commercial systems, however, indicate those men out of the vast army of experimenters who have made the most definite contributions to the advance of the art, even though they might not recognize the apparatus bearing their names.

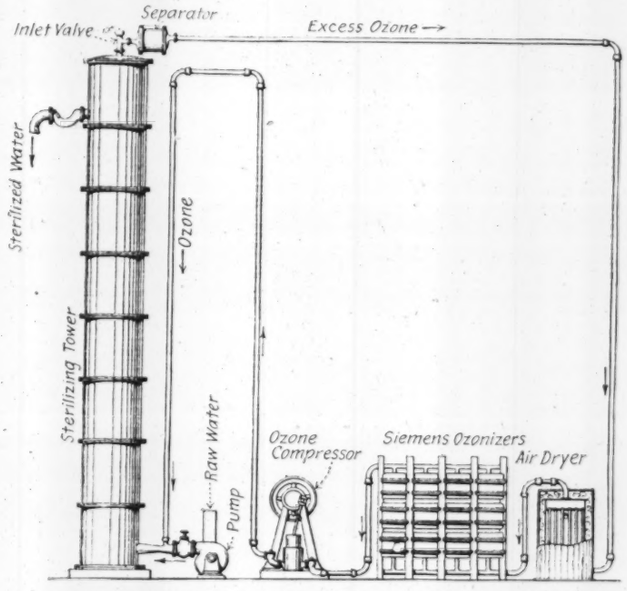


FIG. 3. DIAGRAMMATIC ARRANGEMENT OF THE DE FRISE SYSTEM AT ST. MAUR, PARIS.

(From the paper of Dr. Samuel Rideal before the Royal Sanitary Institute.)

In comparing the performance of various ozone generators, it is necessary to closely define the terms and quantities involved. It is necessary in all cases to ascertain whether or not the stated power consumption includes step-up transformer losses, generator-tube losses, auxiliary requirements, etc. The concentration of yield should always be stated for a given efficiency, as the latter rises with decrease of the former. It is especially necessary to know what methods are used for the determination of the amounts of ozone generated. For instance, from about 1880 to 1900 an acidified solution of potassium iodide was generally used to absorb the ozone from a given quantity of air and thereby test the ozone output of a generator. Sometimes the solution used was neutral at first and acidified only after the absorption. Discrepancies noted in the results were explained in 1901 by two German chemists, Ladenburg and Quassig. They proved by gravimetric checks that the results with the neutral solution alone were reliable. The discrepancies were later shown to be due to the formation of hydrogen peroxide, H_2O_2, which gave a similar reaction with the iodide.

It is also necessary to be sure that the yield of ozone is compensated for nitrous compounds which liberate iodine in the test solution of potassium iodide and increase the apparent yield and concentration of ozone.

European Commercial Systems.

The earliest serious attempt to produce and utilize ozone on a commercial scale was that of Baron Tindal at Oudshoorn in Holland during 1893 and at Paris during 1895 and later. Tindal started with the very simple arrangement of two parallel metal plates, between which a potential difference of 50,000 volts was maintained. To check any rushes of current which would accompany a chance arc or spark, he placed a choke coil in the high potential circuit. Air was drawn between the two plates and by passage through the more or less silent discharge, some of the oxygen was condensed into ozone. The yield of this generator was stated to be some 3 or 4 grams per KW.-hr., but it is probable that even these low figures should be reduced to 1.5 or 2.5 grams on account of the determination methods then employed. An improvement was soon made in this original arrangement by substituting sheets of wire gauze for the plates.

THE DE FRISE SYSTEM.—Tindal erected an experimental water-purifying plant at St. Maur, Paris, on the River Marne. The experiments here did not show any startling economy in the purification of water, and the plant at St. Maur has passed through many periods of reconstruction. It exists to-day, however, enlarged and in commercial operation, still using some of Tindal's original designs, although much modified. Tindal's generator was early replaced by that designed by one Schneller. In this generator one of Tindal's flat plates was replaced by a comb from which the brush discharge could more easily stream. Disruptive discharges—arcs and sparks—were checked by a column of liquid resistance in the high tension circuit. Further improvements were made on this generator by one Vandersleen, but no commercial apparatus was developed until Chas. de Frise acquired the rights of the three previous workers. This system is known by some as the "Tindal-Schneller-Vandersleen," and by others as the "De Frise." The generator, shown in Fig. 2, was used for a while, but it was later discarded by De Frise for the one devised by Werner Siemens, to be described later. The generators were cooled by the water jacket shown between the iron and brass walls. The trough is connected to one terminal of the high tension circuit and also to the earth. The serrated brass plate, from which the brush discharges stream, is connected to the other terminal of the high-tension circuit through the liquid resistance contained in the vertical tubes. These tubes have platinum electrodes.

St. Maur Plant.—The arrangement here is shown in Fig. 3. One typical feature of Tindal's original scheme still retained is the sterilizing tower. This was essentially a series of enameled cast-iron pipes with perforated celluloid plates at the joints. Water and ozone are pumped into the bottom of the tower simultaneously, at a pressure of 10 to 15 lbs. per sq. in., and an intimate mixture of the two is obtained by passing through the perforated plates.

In the arrangement shown by Fig. 3 double-acting compressors (6 ins. diameter by 8 ins. stroke) drew air through the ozonizers and forced it through the sterilizing tower. These towers were built in 20-in. sections and the diaphragms had 0.027-in. holes. The water taken from the river Marne is passed through rapid roughing filters before being pumped into the sterilizing towers as shown.

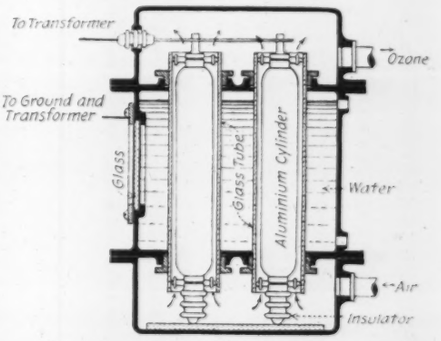


Fig. 4. Siemen's Ozone Generator.

Increased economy of operation is said to have been secured since the Siemens generators were substituted. Dr. Samuel Rideal, of London, who made extensive studies of the St. Maur plant in 1908, reported that 57 KW.-hrs. per 1,000,000 gals. (Imperial) was required for the sterilizing operation and 76 KW.-hrs. per million gallons for pumping. These figures would be reduced to 47.5 and 63.4 KW.-hrs., respectively, per million U. S. gallons.

This plant will be enlarged to treat 20,000,000 gals. per 24 hours. Half of the plant will have the De Frise system as described here (but with Siemens ozone generators). The other half of the extension will be made with the Otto-Abraham Marmier system described below. The present roughing filters will be employed, the speed with which the water is passed through being increased to secure the proper supply.

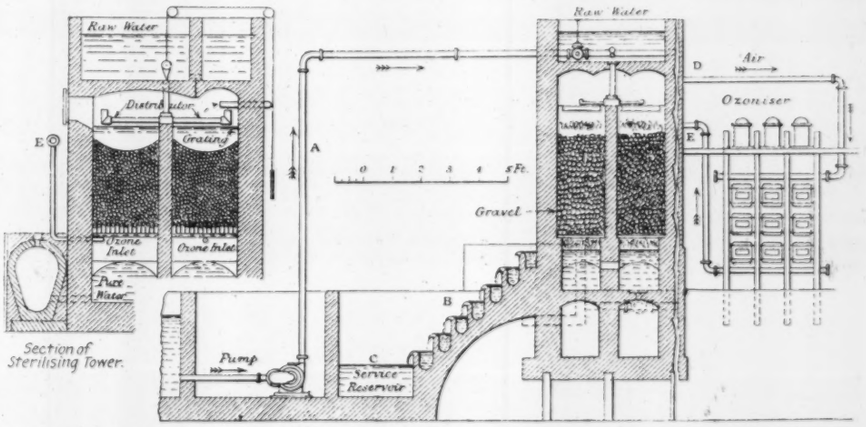


FIG. 5. SECTIONAL VIEWS OF THE SCHIERSTEIN, WIESBADEN, OZONE WATER-TREATING PLANT.

The cost of the 10,000,000-gal. De Frise extension has been estimated by the engineer of the plant as follows:

Ozone plant (with stand-by capacity)	$75,000
Motive power	37,500
Buildings	37,500
	$150,000

The estimated annual expenses, including interest, sinking fund, labor, fuel, etc., is placed at $23,400, or at the rate of $6.40 per 1,000,000

gals. (Imperial) treated, corresponding to $5.34 per million U. S. gallons.

THE VOSMAER SYSTEM.—A generator, in many ways similar to the Schneller design used by Baron Tindal, was devised by A. Vosmaer who arranged a water-purifying system with the assistance of Dr. A. Lebret, a bacteriologist. Plants were erected at Schiedam and Nieuwersluis, Holland. In the Vosmaer generator, the comb from which the brush discharge of electricity was to stream was placed parallel with a long, flat, nickel "receiver" in an enclosing metal tube. By some investigators, at this time, it was felt that the presence of a solid dielectric between the two electrodes of an ozone generator added unreliability of action though preventing sparks and arcs. Therefore Vosmaer permitted only air to come between the electrodes—the air which was to be ozonized. The troubles due to arcs and sparks were designed to be obviated by inserting inductance in series and capacity in parallel with the ozone generator.

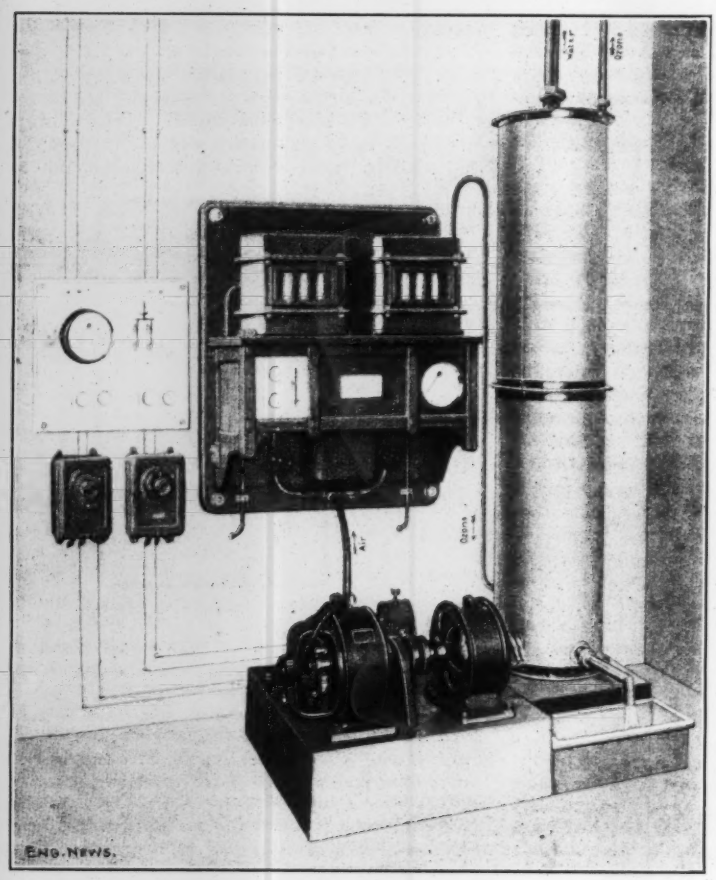


FIG. 6. SMALL SIEMENS-HALSKE OZONE WATER-TREATING PLANT.

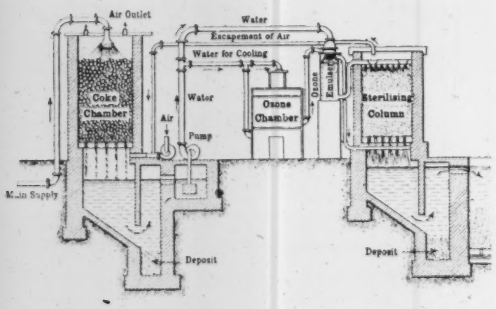


Fig. 8. General Arrangement of Otto-Abraham-Marmier Ozone Water-Purification Plant at Nice, France.

(From London "Electrician," May 21, 1909.)

A feature of this water-treating system was a tall counter-current sterilizing tower, into the top of which water was pumped and into the bottom of which the ozone entered. The head on the ozone inlet made an ozone pump necessary. The air to be ozonized was dried previous to entering the generator.

Tests made in 1904 on the Nieuwersluis plant showed a production of 15 grams of ozone per KW.-hr. at a concentration of 1.6 grams per cu. meter of air. As these figures reported are not very recent, they also are open to a possible 40% (approximate) reduction on account of determination methods then used. Rough filtered water was treated and the introduction of as little as 3.6 grams of ozone per cu. meter gave a reduction of 68,000 to 1 bacteria per c. c., but when the amount of ozone was cut to 2.7 grams the reported reduction was from 56,000 to 9 and with 1.8 grams of ozone from 42,000 to 54. The reduction of organic matter was poor, however, —being from 25% to 10% in the cases noted.

The Vosmaer System in America.—The American rights for this system were acquired by the United Water Improvement Co., of Philadelphia, but the Vosmaer apparatus was superseded in 1907 by the designs of Mr. J. H. Bridge.

The Vosmaer system was tried in an experimental plant at Jerome Park, New York City, in 1906, though here the generator was called the "H. Blanken" and the pre-drying of the air was by refrigeration. The official report on this plant stated that the operation was uncertain and required about 800 KW.-hrs. per 1,000,000 gals. of water treated; only 200 KW.-hrs. of this went into the production of ozone, the rest being about equally distributed on the blowing, refrigerating and pumping. (A brief abstract of a report on these trials will be found in Engineering News, Nov. 21, 1907.)

SIEMENS SYSTEM.—Siemens & Halske constructed a large ozone generator at Berlin for experimental work about 1896, and in 1898 this firm constructed an experimental water purification plant at Martinikenfeld. These experiments were sufficiently successful that larger installations were made for the towns of Paderborn and Wiesbaden. In 1902, the plant at Paderborn was turned over to the city for operation. This was the first commercial ozone plant in Germany, and is reported to have been treating 500,000 gals. of clear water per day since 1902. The plant at Schierstein, Wiesbaden, was completed in 1903, but it has not been in continuous operation, as the Schierstein wells are only a reserve supply. Moreover, as the Schierstein wells are suspected of being contaminated at rare intervals only, it seems probable that the ozone plant was installed rather to satisfy the very conservative doctors at this health resort and to give the makers an opportunity to try out their apparatus on a commercial basis, than to satisfy a real need. (See Engineering News: 1904, Jan.-June, p. 535; 1906, July-Dec., p. 34.) The whole plant was arranged in two units interchangeable in whole or in part. The maximum capacity was for the treatment of 250 cu. meters per hour (66,000 gals., or 1,580,000 gals. per day). The Paderborn plan is now being enlarged to have a daily capacity of 1,000,000 gals.

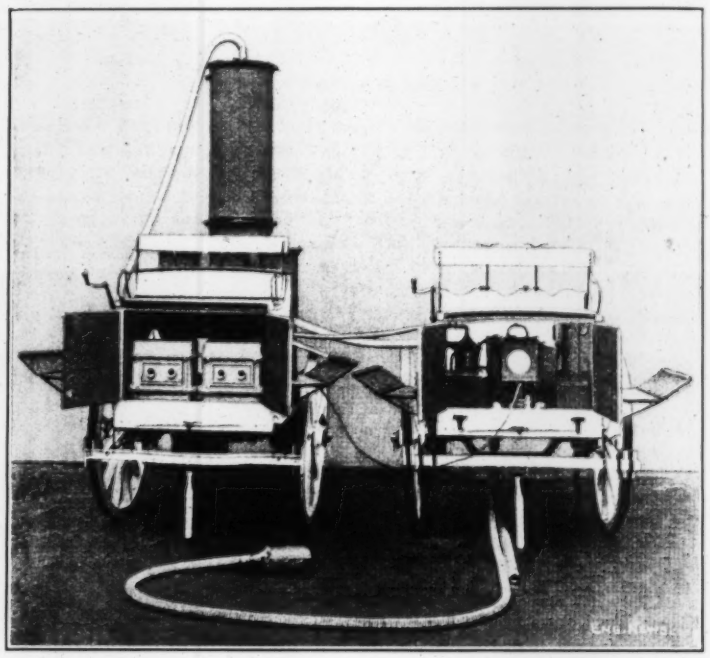


FIG. 7. SIEMENS-HALSKE, MILITARY, PORTABLE, OZONE PLANT.

After experimental trials of tube and plate ozone generators, the tube type shown in Fig. 4 was adopted. These tubes will be seen to be one of several modifications of the old Berthelot tube. They were used with a potential of 8,000 volts. The typical arrangement of the straight Siemens type of plant is shown by Fig. 5.

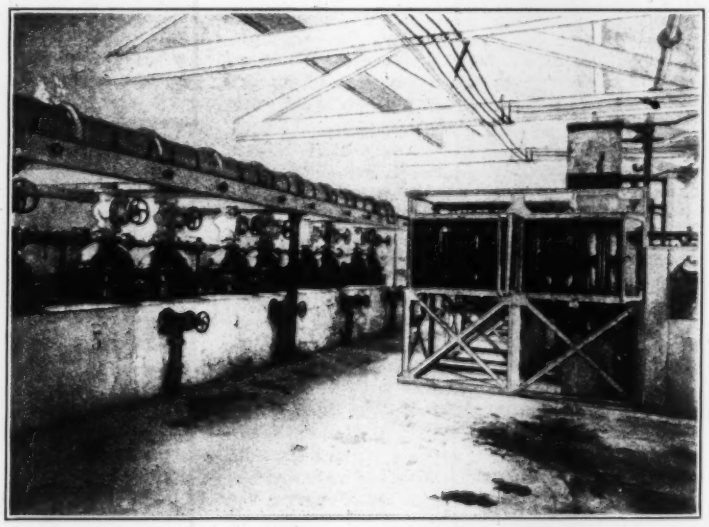


FIG. 9. GENERAL VIEW OF OZONE GENERATORS AND "EMULSERS"; PLANT AT NICE

(From London "Electrician," May 21, 1909.)

Curves have been published showing that the

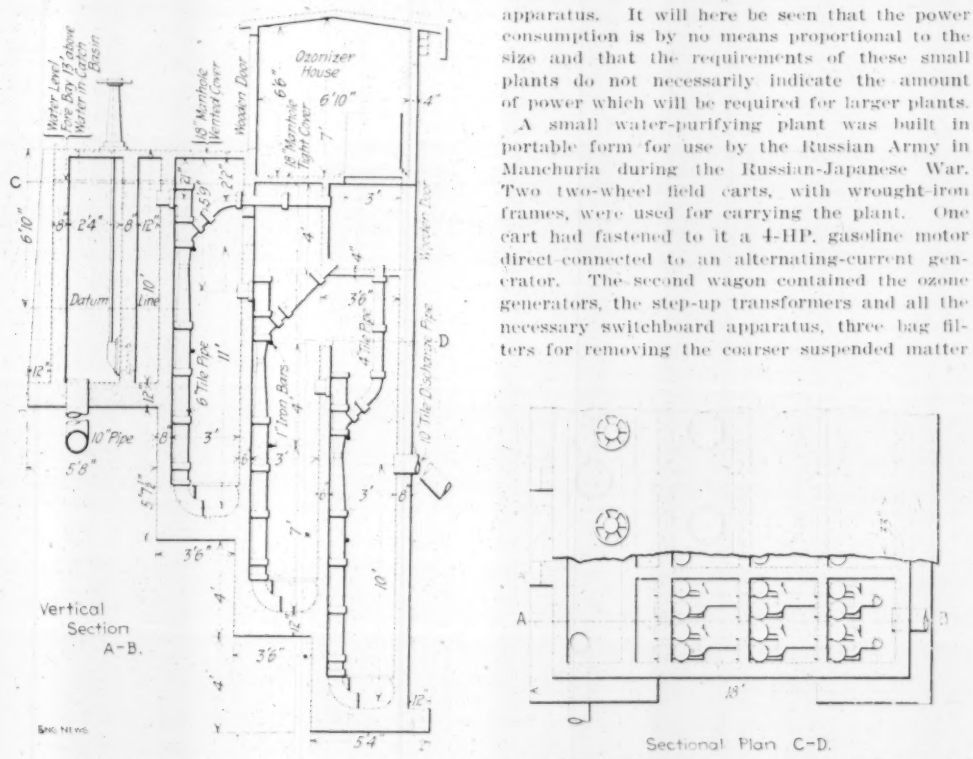


FIG. 11. ARRANGEMENT OF STERILIZING WELLS; BRIDGE PROCESS AS INSTALLED AT ANN ARBOR, MICH.

Siemens ozone generators have an output of from 62 grams per KW.-hr. for a concentration of 1 gram per cubic meter of air down to 47 grams per KW.-hr. for concentrations of about 2.3 grams per cubic meter and to 17.4 grams per KW.-hr. for 4.4 grams concentration. These figures are for the generator alone, and do not include transformer losses which one may expect to be something less than 5%. As Siemens & Halske have used the approved methods of determining ozone since such methods became generally available, it is probable that these figures given are subject to no reduction on that score. This firm is exploiting in the United States, as well as abroad, small plants for domestic and similar service. These have capacities for treating from

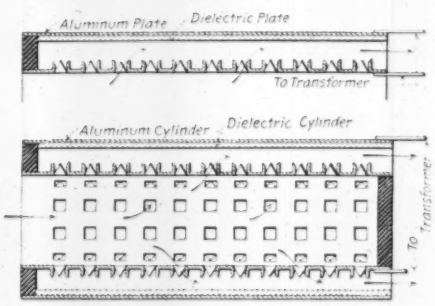


Fig. 10. The Plate and Tubular Ozone Generators of the Bridge System.

800 to 2,700 gals. per hour (9,200 to 65,000 gals. per 24 hours). The ozone generator and the step-up transformers are carried on a wall bracket with a small switchboard, as shown in Fig. 6. A small motor-driven blower and water pump is needed, and if alternating current is not available a small rotary converter may be required. Automatic devices are provided so that when the alternating current fails the supply of raw water is stopped. The treating tower is a large vertical steel pipe filled with flint stones, but working exactly like the larger towers shown in Fig. 5. A 700-gal. plant of this type requires a total of 1 KW. power input and other plants need up to 2.3 KW. for the 3,000-gal. size. Similarly, figures for the larger municipal water-treating plants are somewhat smaller in proportion. For instance, the Wiesbaden plant requires some 40.5 KW. for the production of ozone, some 33 KW. for the water pumps and 1.5 KW. for the other small apparatus. It will here be seen that the power consumption is by no means proportional to the size and that the requirements of these small plants do not necessarily indicate the amount of power which will be required for larger plants.

A small water-purifying plant was built in portable form for use by the Russian Army in Manchuria during the Russian-Japanese War. Two two-wheel field carts, with wrought-iron frames, were used for carrying the plant. One cart had fastened to it a 4-HP. gasoline motor direct-connected to an alternating-current generator. The second wagon contained the ozone generators, the step-up transformers and all the necessary switchboard apparatus, three bag filters for removing the coarser suspended matter

and finally the sterilizing tower. This tower was built in two sections, and when finally assembled was about 8 ft. high.

This firm is marketing a simpler apparatus for the treatment of air for assembly halls, restaurants, etc. It is evident that the apparatus may be made very simple as it is merely necessary to generate the ozone in the regular tubes and to discharge it into the air. Such air-treating plants, of course, can be expected only to oxidize organic products of respiration and to otherwise deodorize the atmosphere.

It has already been noted that the Siemens ozone generators are used by De Frise at St. Maur, Paris. It is now announced that Siemens & Halske have combined their water-purification system with the De Frise, forming what is to be known as the Siemens-De Frise. It is claimed that the combined system is more efficient and satisfactory than either of the constituent systems and that within the last few months several contracts have been made for installing plants for treating 1,000,000 to 10,000,000 gallons of water per day.

OTTO-ABRAHAM-MARMIER SYSTEM. — A system of ozone production and a process for the ozone purification of water, better known in Europe than in America, is commonly known as the "Otto," but more correctly called the "Otto-Abraham-Marmier." This process is under the control of the Lahmeyer Electrical Co., of London, W. C.—for certain parts of Europe, although the Cie. Générale de l'Ozone is exploiting it in France. Like the De Frise (Tindal-Schneller-Vandersleen) system, this is an outgrowth and a consolidation of several designs.

The old Otto generator seems to have been discarded when the Otto system was consolidated with the Abraham-Marmier, the generator of the latter surviving in one form or another. The Otto generator, according to old descriptions, had fixed flat electrodes about 1 in. apart with radial arms. Between them a dielectric plate of similar shape was rotated, so that, for parts of a revolution, only air came between the electrodes and, for parts, a dielectric screen was inserted between them to help subdue chance arcs and sparks.

The Marmier-Abraham generator had parallel, glass-covered, water-cooled electrodes, between which a potential difference of 40,000 volts was said to be maintained. The air to be passed between the electrodes was first dried in a chamber containing pumice stone and sulphuric acid. The production of ozone by the older Marmier-Abraham apparatus was reported at the time to be 15 grams per KW.-hr., but this should probably be reduced, for comparison to present figures, to 9 or 10 grams per KW.-hr., on account of obsolete determination methods. The Marmier-Abraham apparatus has been used successfully at a water-works near Lille, France, ever since 1898, and much of the development work on the present Otto-Marmier-Abraham system seems to have been worked out there. It is reported that this plant at Lille had a capacity of 1,000,000 gals. per day, and operated at a total claimed cost of about $10 per million gallons of water treated.

The Nice Plant.—The latest type of this system is the 5,000,000-gal. plant at Nice, France, although similar plants of small capacity are installed at a half dozen other towns, and it is reported by the Lahmeyer Co. that six-million

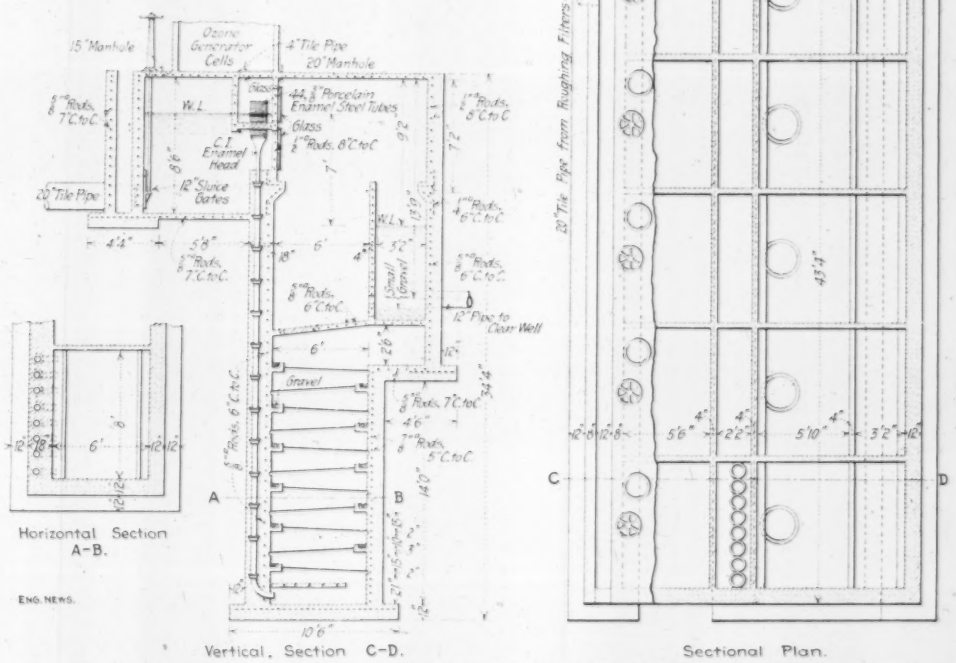


FIG. 12. ARRANGEMENT OF STERILIZING WELLS; BRIDGE PROCESS AS INSTALLED AT BALTIMORE, MD.

gallon plants are already under construction in some ten towns.

One form of the Otto-Marmier-Abraham plant used generators with hollow water-cooled electrodes, one of which had a large hole in its center through which the air to be treated was passed. Glass plates separated by glass strips were interposed between the electrodes. The grounding or short-circuiting of the electrodes by the stream of cooling water which passed

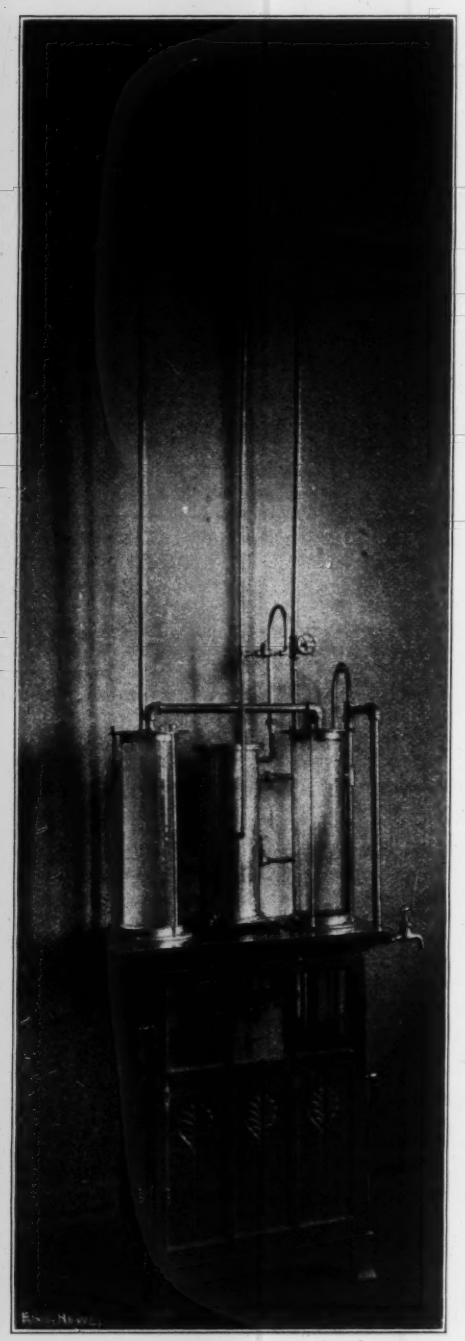


Fig. 13. Small Bridge System, Water-Treating Plant,

through them was prevented by a rain separator placed on top of the generator.

In the plant at Nice, a departure from this design of generator has been made. An accurate description of this generator is lacking, but apparently one set of electrodes is formed by two glass plates coated on the outside by tinfoil and connected to one of the terminals of the high-tension transformer. One plate of each set has at its center a hole through which air is drawn into the space between the electrodes. The opposing electrode appears to be a set of grounded cooling coils. Four sets of electrodes are enclosed in a glass and metal box, from which the ozonized air is drawn.

Direct current at 110 volts is transformed into alternating current at 20,000 volts and 500 cycles for the ozone generators.

The ozonized air is passed directly to an "emulser," so called,—a glass injector in which the water to be treated draws in the supply of mixed ozone and air much like a mercury air pump, it is said. This piece of apparatus serves then both to draw the charged air to the treating chamber and to intimately mix it with the raw water. The water after this mixing passes down through chambers filled with smooth flint stones. As the treated water escapes from the sterilizing chambers, the air and ozone is freed, but confined to the chamber underneath the sterilizing chamber, and from here it is piped back to the mixers. All conduits for air or water are of stoneware. The air is chemically dried before passing to the ozone generator.

The older plants of the Otto-Abraham-Marmier system are reported to have produced ozone at a concentration of 5 or 6 grams per cu. m., with an output of 37 grams per KW.-hr. This figure is probably subject to the 40% reduction on account of obsolete determination methods noted before. The plant at Nice is reported to generate at present about 33.5 grams of ozone per KW.hr., and this figure seems fair, though the determination methods are not known to us. This evidently does not include transformer and other losses. It is also stated that 78 KW. is needed for the generating apparatus and 26 KW. for the pumps. Up to the latest reports the plant had not been working at full capacity—only up to 4,500,000 gals. per day, so that such figures as are available are of only very general interest. A general arrangement of the plant is shown by Fig. 8, and the ozone generators in Fig. 9.

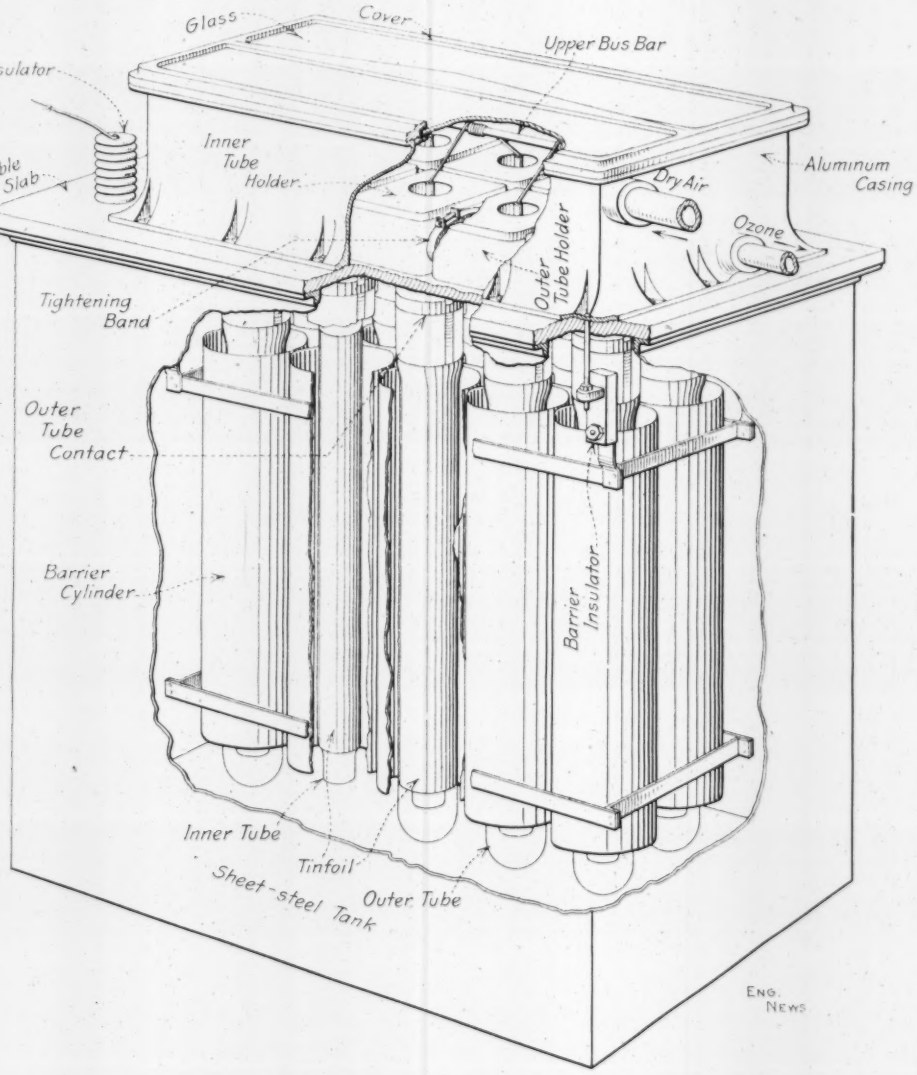


FIG. 14. PERSPECTIVE VIEW OF A TEN-TUBE OZONE GENERATOR.
(Gerard Ozone Process Co.)

American Commercial Systems.

BRIDGE SYSTEM.—It has already been noted that the United Water Improvement Co., of Philadelphia, received the patent rights for the Vosmaer and Lebret apparatus only to abandon them, and to substitute for that system the one devised by Mr. J. H. Bridge. The differences in the two systems were radical; the Vosmaer generator had no solid dielectric between the electrodes, while the Bridge generator did have such partitions between its plate or tubular electrodes; the Vosmaer plant had a condenser and choke coils in the circuit to prevent arcing (and the production of nitrous oxides) while there were none such in Mr. Bridge's arrangement; in the older system the tall treating tower made necessary a pressure of 15 lbs. per sq. in. on the ozone blower while, in the latter, a well replaced the tower and the entering water drew in, by suction, its own supply of ozone.

Drawings of the Bridge generators have not been made public, from which the details of construction can be shown. The principle of the design, however, is shown in Fig. 10. The electrodes are of aluminum and may be either of two forms—plate or tubular. The idea back of the design is to pass the air through peculiar perforations so that each jet should be completely surrounded by the brush discharge about each hole and should also have to pass along and through these discharges.

The three most notable plants constructed on the Bridge system are those at Lindsay, Ontario, Ann Arbor, Mich., and Baltimore, Md.

Lindsay Plant.—The first of this company's plants to be placed in commercial operation was that at Lindsay, Ontario, and as this plant has received much discussion, mostly favorable but some otherwise, it seems of interest to present some of the details of design. The plant is located at the town pumping station, taking water from the Scugog River, which is a sluggish stream running from a shallow lake. The water is highly charged with vegetable matter, derived from the lake and

surrounding swamps, and has an unpleasant odor and taste at most times of the year. As a result, the residents of Lindsay have used ordinary well water largely, and typhoid fever has often been prevalent. The new system includes a rapid preliminary filter, an ozone generator house, a

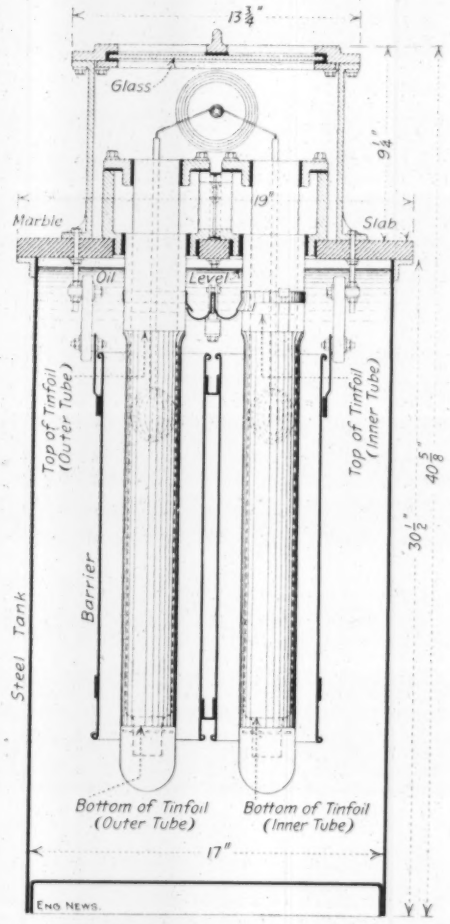


Fig. 15. Cross Section of Gerard Ozone Generator Showing Assembly of Parts.

sterilizing well (some 30 ft. deep and about 6 ft. square), and a purified-water basin from which the supply is pumped into the town mains. This scheme of arrangement is shown in Fig. 12. In this plant the greatest simplicity has been sought. The water flows without pumping through the sterilizing apparatus to the pumps which deliver it to the mains. The flow of water through the sterilizing wells draws the ozonized air from the generators, and with the exception of a ⅛-HP. blower it is said that there is not a moving wheel about the ozone plant.

With a working head of 4 or 5 ft. the aspirator shown in Fig. 12 is claimed to deliver equal volumes of ozonized air and water. In view of the poorer performance of the best aspirators or injectors on the market this claim is remarkable in some ways. The concentration at this plant is about 1 gram per cubic meter of air and about 3,800 grams of ozone are used here to treat 1,000,000 gals. of water. This amount of ozone is obtained, it is stated, with an expenditure of about 70 KW-hrs. under normal conditions. The town pays $35 per HP.-year for electrical energy so that the cost of energy for treating is claimed to be only about 37.5 cts. per 1,000,000 gals. The plant is operated by the regular employees of the pumping station, so that no other costs have been included. The cost to the town has been $8,250, including enlargement from 1,000,000 to 1,500,000 gals. capacity. The total operating cost per million gallons, exclusive of labor, may be computed as follows:

Interest at 5%	$0.755
Depreciation at 2½%	0.377
Energy	0.375
	$1.507

The plant has been subjected to tests by Dr. Archibold, Demonstrator of Bacteriology at the University of Toronto. The average bacterial count of raw water was something over 400. After rough filtration it was about 100, and after sterilization about 19. No B. Coli remained in the sterilized water, although present in the raw and in the filtered water. In one test the raw water was artificially fouled by stirring up the mud in the pre-filter. At this time the bacterial count was 1,500 in the raw water, 500 in the filtered and 12 in the disinfected. There have been no cases of typhoid fever in the city water districts since the plant started in October, 1908, and there has been a marked reduction in children's intestinal diseases during this period. The taste and smell of the swamp and the discoloration are all removed by the ozone treatment.

The pre-filter is a tank of reinforced concrete, 12 × 15 ft., holding 3 ft. depth of coarse sand. The pre-filter is cleaned by simply reversing the current of water, the wash water coming from the city mains under a pressure of 60 to 100 lbs. per sq. in. The ozone generators occupy a small brick building, 8 x 10 ft., built against the pump house. City current is brought into the building at 1,060 volts, and is delivered from step-up transformers to the generators at 10,000 volts. Each of the two ozone-generating units has its own transformer and an independent air inlet and outlet. Nothing is done to free the air from moisture admitted to the ozonizer. It is stated that the difference in the output does not justify the additional expense in first cost and operation of a refrigerating machine or of chemical dryers. Nothing is said of the effect of moisture on the condition of the apparatus or on the composition of the product.

The generators in this plant are of the perforated-plate type described before, with a solid dielectric between the plates.

Baltimore Plant.—The Baltimore County Water & Electric Co. has a plant patterned by Messrs. Wehr, Walden & Dukehart, of Baltimore, Md., after the one at Lindsay. This plant has been constructed and placed in experimental operation. It is expected that it will go into commercial use within the next few weeks. There are here four units, each designed to treat 2,000,000 gals. per day. It was not considered that preliminary or rough filtering would be necessary at this plant, but as the water is discolored a preliminary filter was built to be used if found advisable. Experiments seem to show that bacteria are sometimes protected by suspended matter and that bacteria removal may be more economical with pre-filtering. The general arrangement of the plant is shown in Fig. 12.

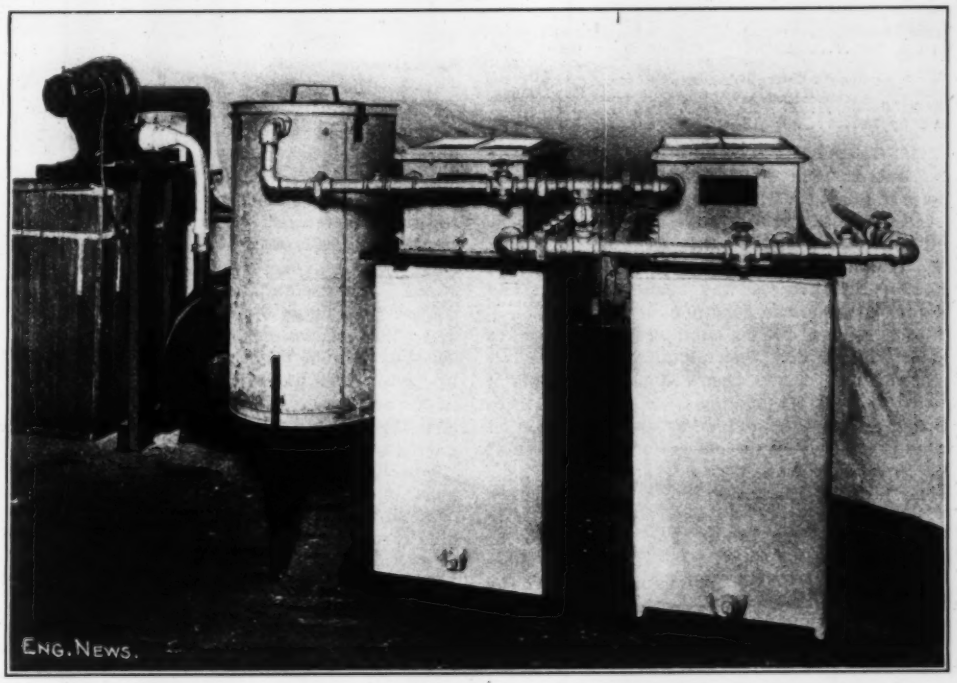


FIG. 16. TWO GERARD GENERATORS ASSEMBLED WITH AUXILIARY APPARATUS.

The Ann Arbor Plant.—Here water from the Huron River is discharged into a receiving tank and from there is passed under a pressure of 3½ ft. head through a battery of aspirators in direct connection with an ozone chamber. The water draws the ozone into itself in passing through the aspirators and then rises through baffle plates loaded with gravel. This is the operation in the first sterilizing well. From here it passes through a second battery of aspirators at a slightly lower level so as to maintain a pressure head of 3½ ft. and draws a fresh supply of ozone through itself and passes a second time through baffle plates loaded with gravel. The process is repeated again in the third sterilizing well, from which it is discharged into a pumping basin, from which the usual water-works pumps deliver it to the city mains. A head of about 11 ft. is available, and it is used in the three steps described. Excess ozone is drawn from the top of the second and third sterilizing wells and re-introduced into the water at the first well. As will be seen from Fig. 11, these wells are, roughly, about 12 ft. deep. The entire plant is 18 ft. long and 12 ft. wide, built entirely of reinforced concrete. Covering the top of the wells is a concrete structure for the ozone generators and the controlling valves. The plant is designed to be operated at any capacity up to the maximum and to be entirely automatic, requiring no labor or attention after starting. The tubular, water-cooled, ozone generators are used, on a potential of 10,000 volts.

The Ann Arbor plant is built in three units, each capable of treating 1,000,000 gals. of water a day. Two of these units have been in operation since the end of 1909, and the other unit will remain unfinished until the water consumption increases. The plant is reported tested daily, and it is found that the raw water usually contains about 2,400 bacteria per c. c., while the average of the treated water is about 5 with an entire absence of B. Coli. The cost of this plant in its present shape to the Ann Arbor Water Co. is slightly less than $9,000. Between 80 and 100 KW.-hrs are used for each 1,000,000 gals of water treated. The electricity is generated at the pump house, and its exact cost cannot be readily ascertained, as the dynamo is driven from a small engine receiving steam from the boilers which supply the main pumps of the station.

The United Water Improvement Co. has put out several small, automatic, compact water pumping plants for use when large central plants are undesirable. One such is shown in Fig. 13. Turning on the water also turns on the current and puts the ozone generator into action. Mr. A. E. Walden, in a paper before the American Water Works Association, June, 1909, reported results of a few tests on one of these domestic

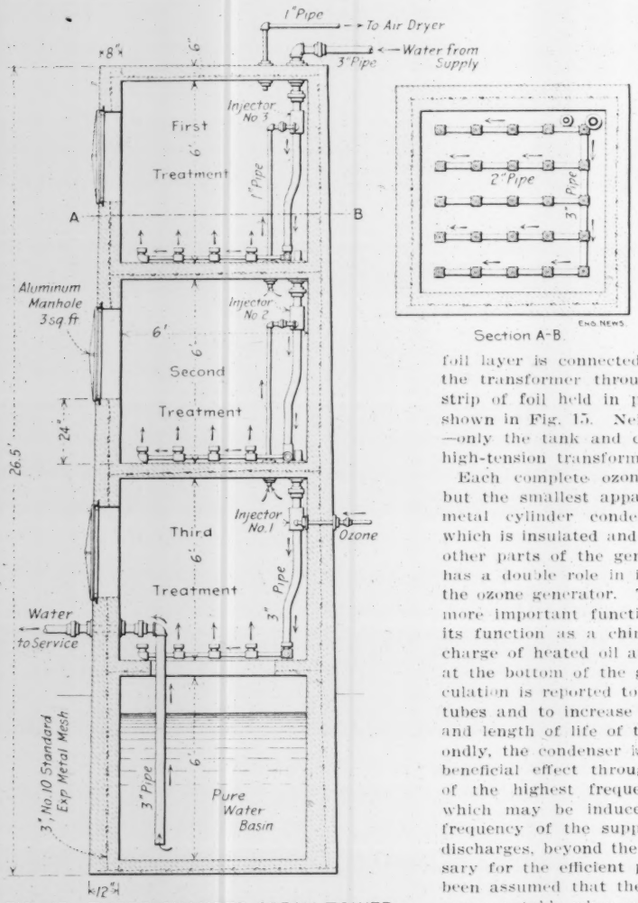


FIG. 17. THREE CHAMBER SPRAY TOWER; GERARD PROCESS.

sterilizers. From his table, the following typical figures are taken.

	Required oxygen.					
	Bacteria				Nitrates	
	Raw.	Ozone.	Raw.	Ozone.	Raw.	Ozone.
March 30, '09....	400	20	0.75	0.65	0.425	0.425
April 5, '09.....	320	7	0.90	0.60	0.450	0.450

	Turbidity		Color		CO_2	
	Raw.	Ozone.	Raw.	Ozone.	Raw.	Ozone.
March 30, '09....	25	25	17.0	10.0	3.0	3.0
April 5, '09.....	18	18	18.0	8.0	3.0	3.0

THE GERARD PROCESS.—Prof. Leon Gerard, of Brussels University, Belgium, who investigated the Tindal process for the Belgian government in 1897, later devised an ozone generator even more like the old Berthelot tube than the Siemens adaptation already noted. In 1907 this process was being developed and adapted to American conditions by Westinghouse, Church, Kerr & Co., as engineers for the Gerard Ozone Process Co. The organization of the latter company has now been completed a couple of years, and all engineering work on the Gerard apparatus for the production and utilization of ozone is handled by the officers of this concern at 165 Broadway, New York City.

The form of the generator is shown in Figs. 14 and 15. Fig. 14, shows a ten-unit tube in perspective section, while Fig. 15, shows the cross-section of a single pair of tubes in more detail. The air to be treated is first dried by refrigeration and is then forced into one compartment of an aluminum box, which rests on a marble slab shown at the top of the containing tank. The air passes from here down through the inner tubes and back up between the inner and outer tubes in a thin stream. During this passage between the two tubes it is subjected to the silent electrical discharge playing across this space. The air finally escapes to a second compartment of the upper encasing box. This second compartment is formed by the porcelain fittings holding the tubes in place. These fittings are tightly joined so as to be air tight. A pipe leads from this porcelain compartment to the exterior of the ozone generator. The outside surface of the outer tubes and the inside surface of the inner tubes are coated with heavy tinfoil, as shown in Figs. 14 and 15. Contact is made to the innermost layer of tinfoil by a small sphere of spring wire, shown in Fig. 15. This is connected to the bus, which is supported on insulators in the aluminum box at the top of the tank. The outer tinfoil layer is connected to the other terminal of the transformer through a spring hook, and a strip of foil held in place by a fiber collar, as shown in Fig. 15. Neither electrode is grounded —only the tank and cover and the case of the high-tension transformer.

Each complete ozone generating tube, in all but the smallest apparatus, is surrounded by a metal cylinder condenser termed a "barrier," which is insulated and entirely independent of all other parts of the generator. This barrier tube has a double role in increasing the efficiency of the ozone generator. The first, and probably the more important function of the barrier tube, is its function as a chimney for the upward discharge of heated oil and the intake or cooler oil at the bottom of the generating tube. This circulation is reported to reduce the heating of the tubes and to increase the efficiency of operation and length of life of the tubes themselves. Secondly, the condenser is claimed to have a minor beneficial effect through damping down certain of the highest frequency electrical oscillations which may be induced over the ordinary line frequency of the supply. While high-frequency discharges, beyond the visible range, seem necessary for the efficient production of ozone it has been assumed that the O_3 molecules in turn become unstable when subjected to the highest frequency radiations and recombine to O_2 molecules as they are swept out of the generator, unless such an auxiliary condenser can damp out the highest-frequency oscillations.

It is the practice of this company generally to force air through the generating apparatus under a slight pressure. There is a tendency towards increased efficiency of production in such practice as has been stated before, and, of course, in leakage of air and the reduction of concentration of ozone is prevented. It also permits a more uniform flow through all the gas passages. However, where it is found desirable under special circumstances to draw the air through the ozone tubes this has been done. In a few of the earlier water-treating plants of this company, the flow of raw water through an injector has served to draw in the supply of ozone and air. In these plants a mixture of air, ozone and water has been discharged into an enameled steel tower having several perforated diaphragms, a little like that used by the De Frise system previously described. This treating apparatus was patented by Mr. A. H. Twombly, whose patents are held by the Gerard Company. The water is pumped to the top of the tower where the inspirator is placed in the water pipe to draw in the ozone. The mixture then flows down a pipe and is discharged into a baffle chamber under the tower. From here it rises through several diaphragms in the tower and is finally discharged at the top.

At present, spraying water into an atmosphere of ozone is favored by this company. The injector is used, however, as an auxiliary, as shown in Fig. 17, which shows a tower for water purification. Into chamber 3, of the tower shown, the main quantity of ozonized air is forced under a slight pressure. The downcoming water passing through the injector (No. 1), is allowed to draw in a small amount of ozone, by-passed from the main supply. The water coming down through the second chamber for the second treatment draws up, by injector No. 2, the ozonized air from chamber No. 1. The incoming raw water similarly draws the ozone from the second treating chamber. Chamber 1 is cleared of any remaining ozone and of the excess air by a pipe which passes to the dryers and to the ozone generators. The water-treating apparatus may therefore work in a closed cycle if so desired. A single tower of the dimensions shown would be designed to treat 340,000 gals. of a bad water per 24 hours. For larger supplies of a bad water several such towers in parallel would draw from the raw supply simultaneously. Where the water was not enough contaminated to require such a thorough and repeated series of treatments, a tower of a single room could be used, as shown in the diagrammatic layout of Fig. 18. Here each tower shown would purify some 940,000 gals., making a plant of the dimensions shown in this figure, having a capacity for about 15,000,000 gals. per 24 hrs.

The space requirements of such a plant as shown in Fig. 18, is seen to be about 7,400 sq. ft. or 500 sq. ft. per million gallons capacity, including the areas between the several buildings, etc. As the roughing filters, if these be necessary, can readily be housed under the ozone generating room, no additional ground space need be considered for them. In considering the volume of buildings required by such a treating plant as shown in Fig. 18, it is seen that approximately 12,900 cu. ft. per million gallons capacity will be required. These requirements are divided as follows.

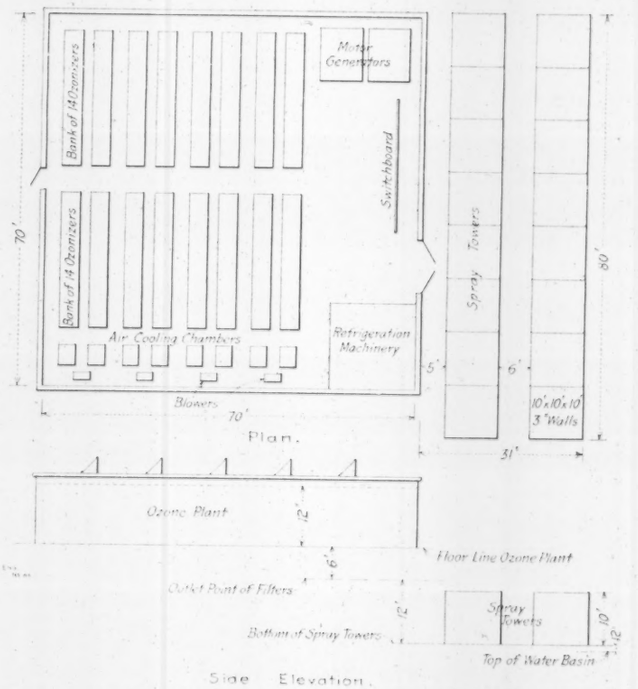


FIG. 18. DIAGRAMMATIC LAYOUT OF PROPOSED 15,000,000-GAL. OZONE WATER-PURIFICATION PLANT; GERARD PROCESS.

Ozone generating	5,200
Water treating	1,700
Pre-filtering	6,000
Total	12,900

Test data reported by the chemist and engineers of the Gerard Co. on apparatus as tested for shipment have been furnished. From these typical extracts shown in the accompanying table are made, indicating the claimed performance of the apparatus.

The ozonized air from the Gerard apparatus, with proper preliminary drying, would be expected to be very low in hydrogen peroxide and the nitrous oxides. Data furnished by the chemist of this company show that with an average concentration of 10 grams of ozone per cubic meter of air only 0.000000125 grams of nitrogen were present as nitrites and 0.0000025 grams as nitrates. No figures have yet been made available showing the relation of humidity and temperature of the air to the amounts of hydrogen peroxide released. In the tabulated data the power required in all cases is stated, including transformer losses as well as generator tube losses. The yield of ozone is given as determined by the decomposition of potassium iodide in a neutral solution according to what has been shown before as practice now generally approved.

In estimating for new installations of ozone water-treating plants, the Gerard company at present specifies 15 ozonizers of the ten-tube type shown in Figs. 12 and 13 for each million gallons of water to be treated per day. The ozonized air is yielded with a concentration of 4 to 6 grams per cu. meter. From 300 to 350 watts per generator, including transformer losses, is required. This is about 125-KW.-hrs. per million gallons of water. To this is added 35 KW.-hrs. for refrigerating apparatus and 25 KW.-hr. for blowing the air through the tubes. If the head lost in the treating plant be considered supplied by a motor-driven pump, then 52 KW.-hrs. more are needed for each million gallons (10 lbs. of pressure head supplied; pump efficiency 60%, motor efficiency 80%).

THE STEYNIS PROCESS.—The process and apparatus for the production of ozone devised by Mr. Jan Steynis and patented Dec. 8, 1908, and April 12, 1910, has many points of novelty and interest. Perhaps the most striking feature is the maintenance of a uniformly low temperature in the ozone generator. This has the important effect of increasing the yield per unit of energy input and it also has other less important effects of making the operation constantly uniform independent of external temperature and humidity and insuring a product of uniform composition and free from nitrogen compounds and hydrogen peroxide. The pre-drying of the air is easily and cheaply done by a slight extension of the refrigerating plant needed for the ozonizer; stated in another way, the refrigeration of the ozonizer is secured with an extension of the pre-drying system.

Mr. Steynis built experimental apparatus for Mr. Cornelius Vanderbilt in New York City in 1909 and tests were made on this by Messrs. L. B. Stillwell, M. Am. Inst. E. E., and H. S. Putnam, M. Am. Inst. E. E., in collaboration with Prof. Wm. Main and Mr. W. F. Doerflinger. After the conclusion of these tests, the Steynis Ozone Co. (30 Pine St., New York City) was formed for the manufacture and exploitation of the apparatus. The equipment of the company's manufacturing plant has recently been completed.

The reports of the tests mentioned showed that the ozonizer generated not less than 105 grams per KW.-hr. at a concentration of 4 grams per cubic meter, including refrigeration of the ozonizer taken by the electrical input of the motor driving the ammonia compressor, and that the product was free from nitrogen compounds and hydrogen peroxide. The following few figures, selected from the log of tests, show the action of the generator, during part of a single day's run.

Concentration, grams per cu. m.	Cu. m. air per hour.	Temperatures, C. Dryer outlet.	Temperatures, C. Ozonizer outlet.	Grams per KW.-hr. ozonizer input.
4.70	42.54	−23°	+3.5°	200.07
4.97	29.97	−23°	+3.5°	148.92
4.00	44.95	−24°	+2.5°	176.29

The average distribution of energy requirements during these tests was as follows:

Ozonizer and transformer	31.0%
Ozonizer refrigeration	21.0%
Pre-dryer	35.0%
Blower	13.0%

It has been found possible to improve upon the experimental plant in designing the apparatus now being manufactured. For instance, the total weight has been reduced from some 5,000 lbs. per KW. capacity to 800 lbs. so that the equilibrium temperatures are reached in 15 minutes after starting where before two hours was ordinarily needed. Generators of the type shown in Fig. 19 are being made of capacities from 0.5 to 5.0 KW. It is claimed that a generator of 1 KW. rating will generate 250 grams of ozone per hour under a concentration of 4 to 5 grams per cubic meter of air treated. This ozonizer rating, of course, does not include the input capacity for auxiliary apparatus other than the step-up transformer.

The electrodes are coils of pipes (through which cold ammonia gas circulates) carrying accurately finished "straps" between the faces of which the electrical discharges play. Four of the seven coils shown (Nos. 1, 3, 5, 7) are grounded and connected to one of the high-tension terminals. The three alternate coils (Nos. 2, 4 and 6) are insulated where their connections pass through the steel casing and from the compressor and piping system by porcelain ammonia tubes. These three electrodes are connected to the ungrounded terminal of the high tension circuit. A dielectric sheet is slipped between the respective electrodes to prevent arcing or sparking. This may be of plate glass ¼-in. thick or of micanite ⅛-in. thick. Between the dielectric and the faces of the electrode straps a small and uniform air gap is left, through which the air must pass and across which the brush discharge takes place. The discharge straps are evenly spaced and the spaces between form pockets in which the air is subjected to the action of the cooling coils to remove the slight increment of heat imparted by each passage through the narrow air gap. The dielectric sheets slide in grooves in the porcelain blocks shown under and above the discharge straps. Four insulated adjusting studs, near each corner of each coil set, fix the length of the air gap between the discharge straps and the dielectric.

The compressed ammonia is carried down at each coil through a concentric inner tube of hard rubber, secured at the inlet valve so that expansion takes place near the lower elbow of each coil. The only loss of heat from the leaving gas to the cold gas just expanded is by conduction along the pipe from the outlet fitting to the expansion point. The conduction of heat inward on the compressor pipes is intercepted by the insulating joints shown in the dome. This latter is kept air tight to prevent objectionable frosting on the pipes therein.

The ozone-generating unit shown in Fig. 19, rests on the drying box and is enclosed to increase the heat insulation. The 1-KW. unit, as encased, is about 7 ft. long by 4 ft. high and 4 ft. wide, and the necessary drying box underneath would have similar dimensions, 6.5 ft., 5

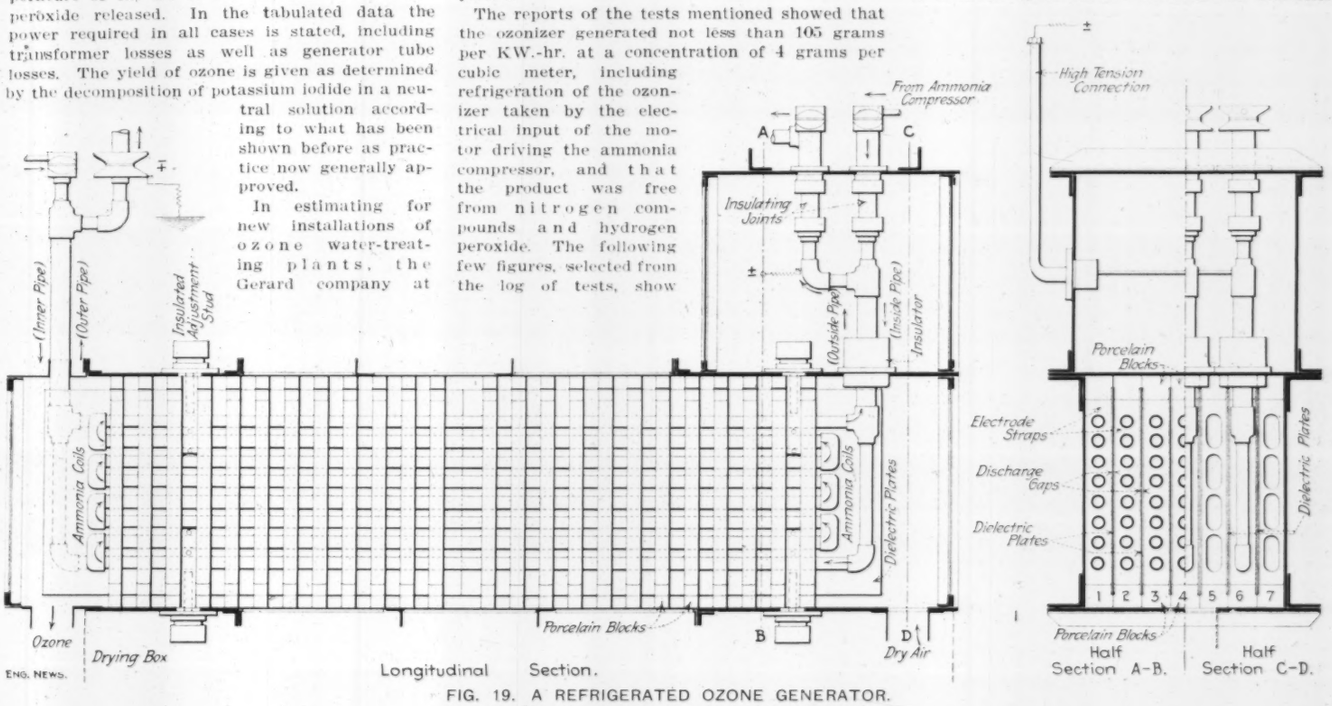


FIG. 19. A REFRIGERATED OZONE GENERATOR.
(Designed by Mr. Jan Steynis, New York City.)

PERFORMANCE OF GERARD OZONE GENERATORS UNDER SHOP TESTS.

Liters, air per hr.	Centigrade temperature. In.	Out.	Volts. High.	Low.	Amperes.	Watts. Ozonizer and Transfr.	Transfr.	Concentration.	Grams per KW.-hr. Ozonizer alone.	Ozonizer and transformer.	Power factor.
3,800	64	51	12,000	105	5.8	380	58	4.7	55.5	47.0	0.624
2,000	66	65	11,500	100	5.5	350	48	8.0	53.0	45.9	0.636
2,000	67	66	14,000	79	9.6	460	38	10.0	47.4	43.5	0.614

ft. and 4 ft., respectively. It is stated that the floor space of the ozone house in a water-treating plant of two to five million gallons daily capacity would be, for ozonizers, cooling box, refrigerating and auxiliary machinery, and water pumps, about 75 sq. ft. per million gallons (volume therefore about 750 cu. ft.). The water-contact apparatus would vary in floor area from 225 to 325 sq. ft. and in volume from 650 to 1,000 cu. ft. Such a plant would treat a water which had no objectionable turbidity or coarse organic materials to be removed. For other waters, the roughing filters would be placed under the ozonizer house, but they would probably require more ground space, the actual amount depending on local conditions in each case.

Using 1 gram ozone per cubic meter of water treated, a million gallons would demand 3,800 grams and the production found by Stillwell and Main (105 grams per KW.-hr.) would indicate 36.2 KW.-hrs. needed per million gallons, exclusive of predrying the air and pumping. The drying of the air, as shown in these tests, for treating 1,000,000 gals., would be 25.87 KW.-hrs. This would be for a humidity of 85% and might be reduced for average operation all the year around with say 60% humidity. With these larger ozone plants, the ammonia compressor would show higher efficiency. The head lost in the treating plant (assumed as 10 ft.), if supplied by pumps of 60% efficiency, driven by motors of 80% efficiency, would demand 52.4 KW.-hrs. additional per million gallons, making the total energy 114.37 KW.-hrs.

Installations will shortly go into commercial operation it is reported. The new generators, it is claimed, will yield 90-100 grams of ozone per kilowatt-hour for a concentration of 6 to 5 grams per meter, including refrigeration of the ozonizer and predrying of the air.

An Instrument for Measuring Acceleration and Gradient.

The mean acceleration of a railway train or of any other moving object may be ascertained from direct observations of average velocities over successive known distances, but this method has the disadvantage of giving only the average acceleration over each space interval for which the velocity is observed. It is difficult, too, to observe accurately the velocity over very short space intervals. An instrument has been devised by Mr. H. E. Wimperis, of London, England, which indicates directly at any instant the acceleration of any vehicle on which it is mounted. It has been used successfully by English railways and the British war office for measuring the starting acceleration, brake retardations and frictional or road resistance of railway trains and of automobiles. It can also be used on both classes of vehicle as a gradient measurer.

The general appearance of the accelerometer is shown in Fig. 1. In the neutral position, the needle stands in the center of the scale, and it is deflected in one direction for acceleration or upward gradient and in the opposite direction for downward gradient or retardation. The scale has two sets of graduations showing respectively acceleration in feet per second and gradient in ratio of rise to length. In use the instrument lies flat on its three legs, with the arrow marked on the dial pointing in the direction of motion. The length of one of the legs is adjustable so that the instrument may be more readily brought to a true horizontal position.

The internal construction, shown diagrammatically in Fig. 2, is remarkably simple. A copper disk, free to revolve about a vertical axis, has a hole drilled through it to move its center of gravity away from the geometric center. Thus when the axis is given accelerated motion in a horizontal direction, the inertia of the eccentrically weighted disk will cause it to revolve. The torque will be directly proportional to the acceleration. The torque on the disk is balanced by a light hairspring and its oscillations are damped by a permanent magnet between whose poles it revolves. The motion of the disk

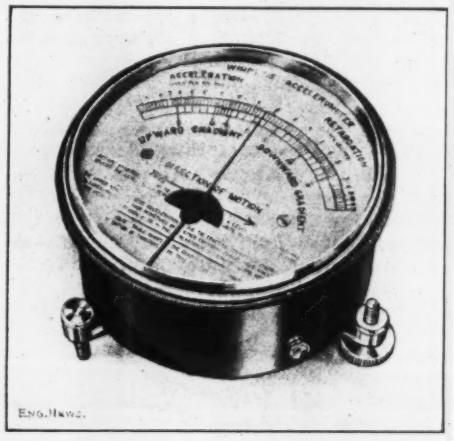


Fig. 1. The Wimperis Accelerometer.

is transmitted to the indicating needle through two small spur gears.

The instrument is made selective by an ingenious arrangement so that it indicates acceleration in one direction only. The indicating needle and its gear wheel are so proportioned that the needle's moment of inertia about its axis of rotation bears the same ratio to that of the disk as the gear ratio. This makes a balanced system virtually equivalent to the two disks sketched in Fig. 3, in which one disk represents the disk and its gear and the other represents the needle and its gear. The two disks are supposed to be exactly similar and to be in frictional contact in the position shown. A force acting on the centers of gravity of the two disks in the direction P at right angles to the line joining their centers of rotation will cause the contacting edges of both disks to move in the same direction. On the other hand, a force in the direction Q parallel to the line joining the centers will influence both disks to turn clockwise, but this they cannot do on account of their rolling contact, and since the moments of inertia are equal the two opposing torques will exactly balance. This explains how the instrument records for any acceleration applied to it only that component which is in the direction of the arrow on the dial (Fig. 1).

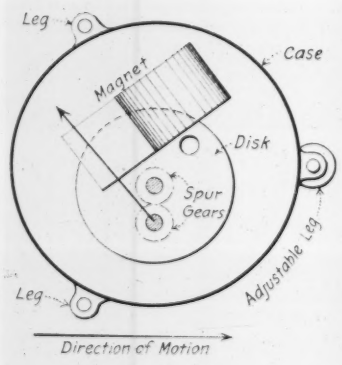


Fig. 2. Diagram of Internal Mechanism of the Accelerometer.

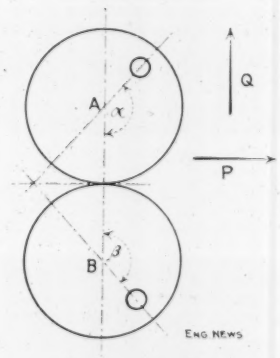


Fig. 3. Diagram Illustrating the Dynamic Balance of the Accelerometer Disk and Needle.
(The angles α and β are equal.)

Applications.

Besides the obvious uses of the instrument, such as measuring the starting acceleration of trains, ships, etc., and measurements of gradient, there are some indirect uses which deserve a brief description. In connection with automobiles, it affords a means of measuring the brake-horsepower of their engines while running on the road. The frictional resistance of the car is first ascertained by observing the retardation while coasting with the engine declutched. Multiplying this retardation by 2000 ÷ 32.2 gives the road resistance in pounds per ton. The velocity attained at a given engine speed can be read from a speedometer and the brake-horsepower can then be computed from the formula

$$\text{B. HP.} = \frac{\text{Road resistance} \times \text{weight of car} \times \text{speed}}{\text{a constant}}$$

Similarly, by observing the average road resistance and the fuel consumed during a trip, the average thermal efficiency can be computed.

To obtain the mechanical efficiency and indicated horsepower of the engine, it is only necessary to measure, in addition, the retardation while coasting with the clutch in gear but with the ignition or fuel supply cut-off.

Mr. Wimperis specifies some of the results obtained with this instrument as follows:

The highest starting acceleration I have measured on a steam train is 0.9-ft. per sec. per sec., and on a tube train 2.4 ft. per sec.². On the District Railway 3.0 ft. per sec.² The highest train braking was 5.8 ft. per sec.²—on the electrified portion of the Brighton Railway. On automobiles the braking runs up to 10 ft. per sec.²

Road resistances on automobiles run from 60 lbs. per ton on the best roads to 120 lbs. per ton on partly made roads, and to 210 lbs. per ton on loose road metal.

The accelerometer is being put on the market in England by Elliott Brothers, Century Works, Lewisham, London, S. E.

MINE ACCIDENTS IN ENGLAND.—The London "Times" (Engineering Supplement) of March 9, prints the following advance tables of accidents in coal mines in England as issued from the Home office. The number of deaths from accidents is the largest recorded since 1873.

	Deaths from accidents.	Death-rate per 1,000 underground workers.	Deaths per million tons of mineral raised.
1900	1,012	1.44	4.25
1901	1,101	1.46	4.76
1902	1,024	1.37	4.27
1903	1,072	1.35	4.41
1904	1,055	1.34	4.29
1905	1,159	1.49	4.64
1906	1,142	1.42	4.31
1907	1,245	1.46	4.41
1908	1,308	1.46	4.75
1909	1,447	....	....

TWO CENTRIFUGAL BOILER-FEED PUMPS have recently been installed in a plant of the Detroit Edison Co., by the DeLaval Steam Turbine Co., of Trenton, N. J. These pumps were designed to deliver 1,600 gals. per min. against a head of 700 ft., while running at a speed of 2,800 r. p. m. It is stated that they have shown an efficiency, under test at full load, of slightly over 60%. Larger ones of the same type are claimed to have shown efficiencies above 85%. These pumps are two-stage. A small bronze impeller is used with special water-labyrinth packings between the impeller and casing. The passage through these is made as tortuous as possible, and the water in the labyrinth, through the drag of the impeller, is given enough centrifugal force to materially decrease the slight leakage. On the rear side of each impeller is a chamber, formed between the casing, impeller and labyrinth packing. This is of the same diameter as the inlet chamber and, being connected to the latter, serves to balance the thrust. One of the impeller bearings, however, is made of a thrust type, to serve in case that the balancing-chamber passages become clogged. Bronze sleeves on the shaft extend from the impeller through the casing and shaft packings to prevent scoring of the shaft. These packings are furnished with water under pressure to prevent air inleakage.

Guide vanes are dispensed with in the diffusion chamber of the casing as these pumps have to operate at various outputs and pressures and the guide vanes are efficient only for a given output and head and, in this case, increase the liability to damage from solid substances which might get into the pumps. All connections are made to the lower half of the casing, so that the upper half and the rotor can be removed for inspection or repair with a minimum of trouble to the boiler plant.

The pumps are directly driven, through flexible couplings, by steam turbines on the same bed plates. The turbines receive steam at 200 lbs. gage, and 150° F., superheat and exhaust into open feed-water heaters, so that practically all of the heat input of the turbine is returned to the boiler-feed water. The pump is controlled by an ordinary excess-pressure type of pump governor inserted in the steam line before the turbine is reached. The ordinary turbine governor then acts as a speed-limit device. There is also an emergency governor on the shaft, to shut off steam at overspeed.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
BOSTON: 43 Tremont Street
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

GEORGE H. FROST, President
CHARLES WHITING BAKER, Vice-President
HARWOOD FROST, Secretary
FRANCIS W. FROST, Treasurer

ALFRED E. KORNFELD, Manager
EDWIN HUNT FROST, Ass't Manager

CHARLES WHITING BAKER, M. N. BAKER, E. E. R. TRATMAN, F. E. SCHMITT, } Editors

SUBSCRIPTIONS

United States and Possessions, Mexico and Cuba, One Year, $5.00.
Canada, One Year: $7.00; Thin Paper Edition, $6.00.
Foreign Countries, Regular (Thick Paper) Edition, One Year, $9.00. (£1-18-0.), 45 Francs or 37 Marks.
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $7.00. 29 Shillings, 35 Francs or 29 Marks. Remit directly to our office.
Pay no money to canvassers for subscriptions.
Remit by Post-Office or Express Money Order, Draft on New York or London, or by Registered Letter.
Notice of change of address should reach us one week in advance of removal. The old as well as the new address should be sent.
Subscriptions cannot be dated to commence with past issues.
All subscriptions commence with current issue and back numbers can be supplied only by special order.
Receipts for Subscriptions will not be sent unless requested, the changing of the expiration number being considered sufficient. The number on the address label indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year. Thus 520 means the 52d week or December 29, 1910.

ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See "Want" Pages.

Copy for regular, or "Contract," Advertisements should be received at least ten days before publication; "For Sale" and "Situations Wanted" Advertisements by Monday, and "Proposal" and "Situations Open" Advertisements by 9 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter.

It is well understood, by those who have given careful study to conservation problems, that petroleum deposits are likely to be among the first of the fossil fuels to become exhausted. The production of petroleum, in fact, has been able to keep pace with the enormous increase in its consumption, only through the discovery of one new field after another. "A short life and a merry one" is the rule with most deposits of petroleum. Many fields whose oil production once played a large figure in the market now yield comparatively trifling amounts. The surface of the earth is now being so rapidly prospected, that an end must come inevitably to the discovery of new underground reservoirs of petroleum. The question is a serious one, what the world will then do for gasolene, kerosene, and a multitude of other petroleum products which have become almost essential to civilization.

The answer to this question will be found, it is probable, in the exploitation of the beds of bituminous shale. The late Prof. N. S. Shaler, in his remarkable book "Man and the Earth," published many years ago, showed the existence in the Mississippi Valley alone of enormous deposits of bituminous shale capable of producing oil and likely to be a source of fuel long after all the accessible coal deposits have been worked out.

The distillation of oil from shale is an industry so little known by engineers that information as to its past history and possible future importance may be of interest. The Canadian Department of Mines has just issued an interesting report on the oil-shale deposits of the Maritime Provinces and on the oil-shale industry of Scotland. The oil-shale industry of Scotland dates back to 1862, and the industry flourished there until the importation of American petroleum introduced severe competition. At first this threatened to cause the extinction of the Scotch works, but the production of other substances than oil from the shale, particularly sulphate of ammonia, enabled them to keep at work, and, instead of the industry dying out, it has actually increased. In 1871, 800,000 tons of shale were distilled in Scotland, and about 25,000,000 gals. of crude oil were produced; in 1904, about 2,700,000 tons of shale were distilled, and nearly 63,000,000 gals. of crude oil were produced. Tests of the Nova Scotia shale which were made at the Scotch oil works indicate that the products from a ton of shale would have a market value of from $3 to $5. From this would have to be deducted, of course, the cost of mining and distillation, the interest on the plant, etc.; but the indications are that a good quality of oil-producing shale might have a greater value per ton than ordinary bituminous coal.

The Chicago harbor problem which, during the past few years has been the subject of so much discussion, is still undecided. Some of the varying points of view were brought out in a recent discussion before the Western Society of Engineers, which is abstracted elsewhere in this issue. Opinions differ widely as to the method of securing a harbor, and as to the location and character of the harbor. There are three plans proposed for creating a harbor. The first is by the municipality, but at the present time this is impossible on account of the city's financial limitations. The second plan is for the Sanitary District to undertake the work under arrangements between it and the city, with a view to the latter possibly taking over the administration at some future time. The third plan is to grant franchises to private interests. The first of these would undoubtedly be the best if it were practicable, but the present city administration favors the third and least desirable method, granting franchises on terms which (so far as made public) do not appear to protect the public interests. The second plan appears to be a reasonably good substitute for the first (if the conditions which make the first impracticable are taken into account), and strong arguments are made in its favor. But (as will be seen by Mr. Mullaney's remarks) neither the first nor the second plans are regarded favorably by the present city administration.

As to the character of the harbor, there are two main propositions: (1) a lake front harbor at the river mouth, leaving the river to be used by lighters and by such vessels as need to reach special points; (2) an inland harbor, utilizing wharfage on the river through the city and along the Drainage Canal beyond the city. The latter is, of course, favored largely by the advocates of a "Lakes to the Gulf" waterway, although it has been shown very clearly that it would be detrimental to commerce to require every vessel in the lake trade to pass in and out of the river when making Chicago a port of call. As to the idea of providing for ocean steamers at Chicago, that is too visionary to need consideration, for reasons which have been amply discussed.

There are, of course, various other propositions. One is for a canal from the lake to the river at some point south of the business district and of the main channel of the river. All the South Side rises in wrath against such a scheme, because it would introduce there the bridge blockades and delays which have worried the North Side and the West Side for so many years.

In general, there seems little prospect that any of the schemes thus far proposed can command sufficient support for adoption at any early day.

The Commercial Utilization of Ozone for Water Purification and Other Purposes.

In another part of this issue we have described the development of various processes for the production and utilization of ozone as a disinfecting and bleaching agent. As stated there, the greatest interest at present centers about its use for purifying city water supplies. Admittedly the treatment of water with ozone appeals to the public in a remarkable degree.

There is now no question as to how ozone acts and no question as to its great efficacy as a destroyer of bacteria and organic matter contained in water. This objectionable organic matter is literally burned up—converted to carbon dioxide. Ozone is frequently called a "sterilizing" agent. Its use can be carried to such an extreme that it will actually sterilize as effectively as any other process, but, in plants for purifying city water supplies however, it is unnecessary and uneconomical to carry the treatment so far. As ozone, or ozonized air rather, is but very slightly soluble in water and, as the bacteria and organic matter are thoroughly disseminated, the ozone works under a great handicap in its attack. Anything that contributes to the intimate mixture of the water and the ozone promotes that attack; but it is obviously difficult, at least with our present knowledge, to secure and keep this intimate mixture of liquid and gas. The wonder is that ozone can be as efficacious as it is.

The oxidizing power of ozone seems to be particularly effective against pathogenic bacteria. As an illustration of the activity of ozone, it may be interesting to quote a few figures secured recently in American laboratory investigations. By spraying a water containing 100,000 to 300,000 colon bacilli per cu. cm. into an atmosphere of ozone, having a concentration of 2.5 grams per cu. m., the bacteria count was reduced to 1 per 5 cu. cm. With a river water, containing from 1,000 to 3,000 bacteria per cu. cm., treated under similar conditions and in the same apparatus, a concentration of 6 grams per cu. m. of air was needed for the absolute destruction of B. coli, but with 2.25 grams concentration, only 1 B. coli was left per 5 cu. cm. However, while only 1 colon bacillus was noted in 5 cu. cm., 150 bacteria were counted per cu. cm., but they were shown to be spore-bearing types. Even with as high a concentration as 6.5 grams of ozone per cu. m. of air, 40 of these spore-bearers were left in each cubic centimeter.

In another series of experiments on a highly contaminated water, approximately 1% sewage, a single treatment with ozone having a concentration of 12 grams per cu. m., and with a consumption of 1.25 grams of ozone per cu. m. of water treated, reduced the bacterial count from 60,000 to 400. A second treatment with ozone at a concentration of 10 and a consumption of 0.77 grams more per cu. m. of water reduced the count to 40, with the probable removal of all B. coli. The bactericidal efficiency of the first treatment was then 99.333%, and of the two treatments 99.933%. A sample of settled sewage was similarly experimented upon with ozonized air in saturation bottles at a concentration of 12 grams. The first treatment reduced the bacterial count from 12,000,000 to 15,000, with a consumption of 9 grams per cu. m. of water. A second treatment, in which 5 grams per cu. m. additional was absorbed, reduced the count to 750. A third treatment with an absorption of 3 grams per cu. m. of water, reduced it to 200 per cu. cm., and a fourth treatment with an absorption of only 1 gram per cu. m. brought the count down to 40. The total consumption of 18 grams in four treatments, then, brought the count from 12,000,000 to 40.

These figures are very interesting as showing what can be done by an imperfect mechanical mixture of ozone and water, but they do not throw the least light, of course, on the commercial practicability of such sterilizing processes.

Turning now to experience in the commercial treatment of water with ozone on a large scale; the plant at St. Maur, near Paris, France, seems to have been longest in commercial operation and to have received the most careful and intelligent study of any large plant from outside sanitarians and engineers. In tests of this plant, made a couple of years ago, by Dr. Rideal, of London, ozone at a concentration of from 1.5 to 1.8 grams was furnished to the sterilizing tower (as described in the article elsewhere in this issue). The average ratio of water to ozonized air was 2.47 to 1. Rough-filtered water, showing a bacteria count of 40 to 320 per c. c., was reduced to a count of 1 per cu. cm. in most cases, and to 2 in a few cases. The presence of B. coli was noted usually in 20 or 40 c. c. before ozone treatment, but never in 100 or 200 c. c. after treatment. The greenish-brown color of the filtrate was changed to the faintest blue tint. The CO_2 content was slightly decreased, in spite of the combustion of organic matter, and the physical

properties were generally unchanged. Neither the chlorine nor nitrate content showed any increase after treatment. This plant has been judged so economical and successful as to justify its enlargement to 20,000,000 gals. daily capacity. It is noteworthy that the De Frise system in use here has succeeded in spite of having to pump water and ozone against a head of some 15 lbs. per sq. in.—a condition which largely contributed to the economic failure of the Vosmaer process in this country. It is also noteworthy that one-half the plant will be built after the Otto-Marmier-Abraham system, in which the ozone is not pumped and the lost head of water is reduced.

In the ordinary run of the ozone water-treating plant at Lindsay, Ontario, raw water coming to the roughing filters shows an average count of 400 bacteria per cu. cm., with B. coli usually present. The filtrate shows 100, with B. coli also, but after ozone treatment the average count is given as 19 with B. coli absent. No information has been given us concerning the physical or chemical properties of the treated water, save that the color and taste have been made satisfactory to the townspeople. It would be interesting to see figures on the nitrogen and chlorine content before and after treatment, but these are not available.

From the description of the Lindsay and Baltimore plants it will be seen that air containing more or less moisture is admitted to the ozone generator. Now there is evidence that nitric acid or nitrogen oxides can be formed, even when arcs and sparks are suppressed, if moist air is subjected to the silent, high-tension discharge of electricity. There are, as yet, no data to show the presence or effect of these compounds at these two plants but it may be presumed that they are formed during part or much of the time. Nitric acid is an active disinfectant, and the nitrogen oxides have such properties though to a lesser extent. Solutions of the acid, as weak as 1 in 3,000, are reported as fatal to organisms like anthrax bacilli. It is possible then, as the nitrogen compounds show up as ozone in common determination methods, that ozone disinfection of water supplies may sometimes be partly chemical. But the presence of such foreign compounds in water treating plants is not important, unless their amount rises so as to become troublesome in the human system, unless they hasten the deterioration of the ozone apparatus, or unless they increase the corrosion of water pipe. For chemical or industrial uses of ozone, however, the pre-drying of the air may be demanded.

There is much misapprehension of what the field of ozone treatment of water really is and what it has to recommend it over other processes. We believe that one of the elements of greatest value to its exploitation is its inherent characteristic appeal to the public. It must be admitted that there is something very attractive to the public mind in the proposition to pass bubbles of ozonized or "electrified" air through a contaminated water. On the other hand the public is more or less suspicious of the addition of chemicals to water, and there are always plenty to aver that the water so treated has "a queer taste." Even with a filtered water supply the public is apt to be suspicious of holes in the filters, even though long years of experience with both mechanical and slow sand filtration has shown that such fears and suspicions are practically groundless.

A second element of great value in the ozone process lies in the ease and quickness of removing color (stain as distinguished from turbidity), taste and odor in cases where filtration and chemical disinfection can do this imperfectly or at heavy expense. It is well, however, to recognize from the start that ozone is effective in disposing of organic matter only, having practically no effect on other impurities except metallic salts.

It has been claimed by promoters of ozone processes that removal by screening of the coarsest suspended matter, followed by ozone contact will be cheaper than any other process of water treatment. It remains to be demonstrated, however, just where preliminary treatment plus ozone contact will be more economical than sedimentation or coagulation and filtration.

It should be remembered, in this connection that, with any filtration of suspended matter which is more than a mere screening, a reduction of the number of bacteria in the water always takes place. Therefore, when something more than screening is needed to remove finely divided objectionable matter, previous to ozone treatment, the other contamination would be removed during that process (extended perhaps) and the ozone contact would seem more or less superfluous.

For determining whether or not an ozone water-purification system is desirable in a given location, no general rules can be made—even laying aside public prejudices for or against any system. There can hardly be a clear definition of either the possibilities or the limitations of ozone processes until many complete series of studies have been made by independent engineers of repute. However, a few restricted statements are permissible to show evident tendencies.

The average costs of the several kinds of water-purification plants would be highly interesting if obtainable. In the present state of the art, however, only the most general comparisons can be made. By examination in the files of Engineering News of the records of a few plants it appears probable that where a plant for treating a clear but contaminated water with ozone has cost $3,000 per million gallons capacity, a slow-sand filter would cost something like $20,000 for the same capacity, a mechanical filter would cost some $10,000 and a plant for dosing with hypochlorite of lime would cost only about $120.

A plant for rough filtration followed by ozone treatment has cost about $5,500 per million gallons capacity. From recent installations it is probable that if hypochlorite dosing were substituted for the ozone treatment the plant would have cost about $2,700 for the same capacity. But this figure is yet to be determined by the operation of commercial plants on a large scale. Theoretically, of course, there is a great advantage in operating a filter at a very high rate and relying on an ozone treatment to dispose of such bacteria as are carried through the filter. Practically the additional complication of a double treatment system is a serious handicap to any such system.

So far as can be seen at present the ozone treatment is best suited to waters which are already satisfactory as regards color, taste, odor, etc., but are dangerous because of sewage contamination. There are many water supplies taken from the Lakes or the St. Lawrence to which this description applies. There are also some underground supplies and supplies from large storage reservoirs which need no treatment except the destruction of possible pathogenic bacteria.

On the other hand, the waters least suited to ozone treatment would appear to be the turbid river waters of the West and South, which require clarification by sedimentation or other methods in any event.

Between these extremes are waters of various grades, some of which, like the swamp-stained waters above referred to, may find the ozone treatment especially advantageous; others, like the clay-carrying waters, require such heavy expense to remove the suspended matter that the bacteria may as well be removed with it.

Of course, no hard and fast rules can be laid down as to what ozone is or is not adapted, until the commercial position of the ozone process is better established. The situation in this respect resembles that which many engineers will recall in the early days of mechanical filtration. The likeness is further carried out in the existence of at least five competing companies exploiting different processes of ozone treatment.

It will be apparent, from study of present demand, that ozone processes seem to have little commercial chance in the field of sewage purification, notwithstanding the large claims made to the contrary. The main object in sewage purification is not primarily to kill the bacteria in the liquid, but to remove organic matter which may become offensive through decomposition. Ozone will, indeed, oxidize the organic matter in sewage if finely divided, but it is in no way feasible to do this on a commercial scale. Disinfection and deodorization of settled or strained sewage is possible, as we have shown above, but at a great cost for ozone and for forcing contact between ozone and effluent. Should the day ever come when this disinfection is demanded, the ozone processes would have to compete against the ease and cheapness of chemical dosing.

At the present rather unsettled stage of development of ozone water-treating systems, it is not safe to say that the apparatus will take care of itself, like the alternating-current transformer for instance. On the other hand, an ozone plant should be as reliable, successful and economical in operation as any other water-treating system if well installed under competent advice and if well cared for and maintained. The ozone generators are hardly to be classed as delicate machinery, although they seem to be put out of service with greater or less ease. The auxiliary machinery—pumps, coolers, etc.—can be made as reliable for use here as anywhere. Of course, if continuity and reliability of operation is to be assured there must be a skilled mechanic in charge and a supply of duplicate parts, as with any other system involving the use of fine machinery.

The processes and apparatus for making and using ozone are still far from fixed. Too many avenues are open for progress to permit great rigidity in design or operating method. Were all the useful patents brought under a single control and were all the ozone-generator designs made available for a competent designer to select the best features from each, an ozone generator of high economy would result. Were all the methods for forcing contact of ozone and water similarly combined, we might get a system with which this could be done, with a slight loss of head. Each successive inventor has devised one or more good features about which he has built up his system. Such a consolidation as is suggested above has taken place in many other mechanical fields, and a similar result may eventually be reached here.

We have devoted chief space to the use of ozone for water purification since that is the application to which inventors are paying greatest attention and in which engineers are to-day most interested. But there are many other uses and great possibilities for ozone in many arts and industries.

Ozone is unique among germicides in having no injurious effect whatever on the higher forms of animal life unless perhaps when breathed at high concentrations or for very long periods of time. Practically all other germicides are either violent poisons or like heat cannot be applied without changing the condition of solid organic matter. We mention here only a few of the applications of ozone which have been proposed or tried to show the possible scope of the processes.

The sterilization by ozone of meats, eggs, fruits and similar perishable food products has been tried with success on a laboratory scale, and may very probably prove a most desirable adjunct of the cold-storage process of preservation. It should probably render unnecessary the extremely low temperatures which have been claimed to impair the quality of the food stuffs subjected to them. Cold-storage plants should be especially favorable for the operation of ozone generators, because of the refrigeration apparatus at hand for drying the air, for cooling the generators, and for promoting the stability of ozone in the air of the treating chambers. Again, while the cold storage process is especially effectual in retarding bacterial decomposition in the interior of meats, etc., certain forms of mold, etc., sometimes grow upon the surface. Ozonized air, for such cases, would be especially efficient in protecting the surface.

The sterilization of vessels, for carrying food or beverages, by ozone has already been practiced in Europe where wine casks have been thus treated. Wines have also been aged in France by exposure to ozone.

For the sterilization of milk, the ozone proces-

would appear to have very great possibilities. The unfortunate effect upon public health of the too-common treatment of milk by such preservatives as formaldehyde are well known to sanitarians. Icing is expensive and difficult to always maintain in extremely hot weather. Pasteurization, or partial sterilization by heat, is objected to by many physicians. Something has been done on a commercial scale in the partial sterilization of milk by nascent oxygen produced by adding hydrogen peroxide to the milk. This, however, is a very expensive process, and there is a chance of introducing acids in the milk through impurities in the peroxide used. Ozone should be much cheaper and more efficient in any plant where treatment is conducted on a large scale. A small ozone plant should find many uses about a dairy, in sterilizing cans and utensils, in treating the water supply and in minor disinfecting operations.

Besides milk, butter, lards, oils, fats and other food products seem to be effectively sterilized and deodorized by ozone treatment, and experimenters are at work to develop such processes on a commercial scale.

For the hospital and in surgery again, ozone would seem to have an enormous field. As a non-poisonous, yet powerful antiseptic, applicable in gaseous form or through liquids, it should be of the greatest benefit to the surgeon. The therapeutic benefits of ozone are already a matter of universal popular belief. Such experiments as have been made tend to the confirmation of this belief, and the possibilities of its systematic use in the treatment of pulmonary and nervous diseases particularly are likely to be thoroughly investigated during the next few years.

It will be understood, of course, in all the foregoing that we have pointed out possibilities or probabilities rather than established facts. The multiform applications of electricity during the past thirty years have all followed from the invention of the dynamo, which gave the world for the first time a cheap and reliable means of producing electric current. The applications of ozone, likewise, may be expected to follow the recent development of machines for economical production of ozone on a large scale.

LETTERS TO THE EDITOR.

The Use of Curve Radii Based on Two 50-Ft. Chords.

Sir: I wish to say a word in defense of the 50-ft. chord radii used in connection with the turnout tables of my book, "Modern Location of Standard Turnouts," reviewed in your Engineering Literature Supplement of March 17.

The criticism in the review that "the use of 50-ft. chord radii might affect the utility of the book" is undeserved, because if it is desired to use 100-ft. chord radii (R'), by using a value of $D = R' + d$ and other functions just as shown in the tables it is obvious that no appreciable error would ensue.

The writer knows from experience that some railroads lay out their curves (those sharper than five degrees) on location on the 100 ft. chord radius scheme and then during construction inconsistently retrace these same curves, forcing their original alinement slightly by using 50-ft. chords, on account of the track men requiring track centers set 50 ft. apart. It would be extremely awkward for the engineer party in setting these 50-ft. track centers to use the 100-ft. chords, hence the inconsistency and forcing.

The writer therefore employed the 50-ft. chord radii in making up his turnout tables so as to make them consistent with the better and more modern practice of laying out curves, and furthermore, wishes to go on record as being an "insurgent" against the old time or "common" practice of using the 100-ft. chord radii. A simple method of using the radii commonly found in existing field books for 50-ft. chord radii is to take half the radius of half the degree of curve.

C. M. Kurtz,
234 Iowa St., San Francisco, Cal., March 28, 1910.

[The standard method of measuring degree of curve by 100-ft. chords permits the use of 50-ft. or other short chords by help of a simple table of short chords. This involves no change of existing data, as does the adoption of an entirely new set of radii.—Ed.]

The Duty of Pumping Engines.

Sir: Prof. Kent's interesting communication in Engineering News of March 10, asking why one pumping engine shows a higher duty than another, can be answered in general terms by stating that it is owing to the variations in the conditions under which different engines are operated. The difference in ratios of steam expansion is immaterial within certain limits, in the face of two other important factors: (1) friction in the machine, and (2) the utility of steam jackets and reheating.

In the two cases cited in the communication referred to (Chestnut Hill with 187.4 lbs. steam pressure, and Albany with 168.2 lbs. steam pressure; or 202.1 lbs. absolute, and 182.9 lbs. absolute, respectively) assuming that a terminal pressure as low as 6 lbs. absolute is reached in the low pressure cylinder of each engine, the ratio of expansion would be 33.66 in the first case and 30.48 in the second.

In the absence of actual indicator diagrams, a comparison may be made upon the basis of the hyperbolic curve, which is quite as good as most engines can produce. Then, so far as steam expansion itself is concerned, if the terminal pressure can indicate the quantity of steam used, and the mean effective pressure can indicate the amount of work done, it follows that the greater the M. E. P. with a similar terminal, the greater the economy found in expansion. Upon this basis, the ratio between the terminal and M. E. P. varies only one-tenth in the two cases, showing 3.5 in the Boston and 3.4 in the Albany engine. By the way, the increase in the duty is only 2.8% (.028) including the "co-efficient" of the experts in each case.

Considering the friction of the engine; here we have an important element affecting the duty figures very materially. Supposing a pumping engine was developing 800 water HP., with 94% efficiency of machine, and showing a duty of 178,497,000 ft.-lbs. per 1,000 lbs. of steam, then the indicated horsepower would be 851, and the steam per I. HP. per hour would be 10.4 lbs. Now, with 25 less I. HP., the rate of steam consumption would not change perceptibly, possibly not at all and, if superior alinement and fine fitting of bearings could so reduce the friction of the machine that the mechanical efficiency could be raised to 97%, then the I. HP. would fall to 825, the water horsepower would remain the same (800, because the work would remain the same), the total steam consumption would fall from 8,850.4 to 8,580 lbs. per hour, and the duty would increase to 185,430,000 ft.-lbs. per 1,000 lbs. of steam. So much for reducing friction.

Considering the matter of steam jackets. There is little room for doubting that in the early days of steam jacketing, entirely too much pressure was carried in the jackets, especially those of the lower pressure cylinders. To illustrate: Several years ago the writer had occasion to try some experiments compressing the exhaust steam in unjacketed cylinders, by early closure of the exhaust valves with the view of determining cylinder temperatures, as indicated by the extent to which compression curves could be carried up, without the assistance of outside heat. After many experiments under conditions which ought to have given reliable data, the results summed up as follows:

High pressure cylinder, no steam jackets.
Initial steam temperature, 365°.
Cylinder temperature indicated by compression, 238°

Intermediate cylinder, no steam jackets.
Initial steam temperature, 270°.
Cylinder temperature indicated by compression, 231°.

Low pressure cylinder, no steam jackets.
Initial steam temperature, 202°.
Cylinder temperature indicated by compression, 174°.

If these relations of temperatures between the steam and the iron cylinder walls, hold good in most cases, it shows how easy it would be to use too much steam in the jackets, and also illustrates the fact that if the jackets are not arranged to get hold of the initial steam, instantly, and dry it out, they will be extremely likely to do a great deal of useless work.

Experiments have also been tried, in which the jacket pressures were increased. The speed of the engine was increased, and more water was pumped, but the duty fell off, because more heat in proportion to the increased work went through the cylinder walls. The increase in the speed was about 3% but the efficiency was lessened. The cut-off in the high pressure cylinder had to be shortened to keep the engine down to normal speed with the jacket pressures increased. Notwithstanding the shorter cut-off, the unnecessary jacket heat sent a good many thermal units to the condenser. There was a certain point of cut off with a certain jacket pressure for the intermediate and low-pressure cylinders, which did the best work. The maximum jacket consumption was 19% of the total steam used and the minimum was 9% but both extremes showed less efficiency of the engine than with the 11% which seemed to be the best proportion under the conditions imposed in that particular case.

When there is a difference in duty of only 2.8% between two pumping engines located 200 miles apart, under different conditions of pressure and service, there are several items which produce a variation, but the above mentioned, are quite sufficient if they happened to come in just right. Referring again to the item of friction; if all of the friction of the Boston engine could be eliminated, the duty would be 190,159,405 ft.-lbs. per 1,000 lbs. of steam. If the friction was so much that the mechanical efficiency fell to 85% the duty would be reduced to 161,936,651 ft.-lbs. per 1,000 lbs. of steam.

Yours respectfully,
Chas. A. Hague.

New York, April 11, 1910.

Some Mooted Points in Reinforced Concrete Design.

Sir: In your issue of March 31, 1910, p. 358, Mr. Edward Godfrey discusses some "mooted points" in reinforced concrete design, 16 points in all. As these points are all essential and fundamental principles, there would be little if anything left of our present theories if Mr. Godfrey's criticism should be allowed to stand unchallenged.

With reference to the first point, it is well known that sharp bends should be avoided in the rods, and Mr. Godfrey cannot claim to have discovered the curved bend. See for instance Mörsch.* But in any case, it is almost impossible to bend heavy bars to a sharp corner, so that where bars are bent cold the shape recommended by Mr. Godfrey is approximately realized.

Under the second point the statement is made that *"the rod receives its stress in increments, which increments can only be imparted where the concrete is stretched"* in tension, for which reason it is incorrect design to bend the rods up near the ends. But under the sixth point this very arrangement is recommended. Further, Mr. Godfrey states that "it is true that there is a shear or a diagonal tension in the beam," but forgets to add that it is true only as long as the beam is a solid mass; as soon as the concrete gets the minute cracks discovered in recent years, its tensile strength is exhausted, and there can be no shear action below the neutral axis. We know that these very small cracks have no significance as far as the strength of the beam is concerned, provided that there is reinforcement to take care of the new distribution of stresses. It is now easy to prove that under these circumstances the stirrups are stressed in tension and thereby ensure the stability of the beam in its "second stage" of loading, while in the "first stage" the stirrups are not stressed. But this second stage is usually realized below the working load on the beam, and the stirrups are therefore necessary tension members and cannot be discarded with the general remarks under item 6.

The remarks under the third point are true. But it is also true that good engineers provide ample anchorage for the bars. The well-taken point of view cannot be turned into a criticism of the profession as a whole. It is hardly fair to blame the engineers for errors committed by individuals who are incapable for want of training; that a great number of structures in reinforced concrete, steel, timber and masonry are designed and erected by incompetents is nothing new.

The fourth point is well taken, and the writer wishes to subscribe to all the statements made in this paragraph.

In regard to the fifth point, Mr. Godfrey has some very unkind words for those who are "bold enough to compare the stirrups with the vertical tension members of a Howe truss." The writer of this letter is one of them, at least to the extent of explaining their action. The actual stresses in the stirrups do not reach the value derived for the tension members of the truss, and they do not usually have to be made as heavy. They do therefore not need full anchorage of 50 diameters, especially as they are embedded in concrete stressed in compression in a direction normal to their own direction at their upper end. As for the lower end, it does not seem so bad to "loop them around the bottom chord"; in fact, it is difficult to imagine a more rational way of anchoring a rod. Give a rope half a turn around a post and pull the two ends toward you in a similar way and see what happens. In addition, the stirrups retard the sliding of the tension chord; compare the very interesting tests described by Mörsch.

Most of the remarks made above will also serve as answer to the sixth point raised by Mr. Godfrey. In addition, let us consider the following remark made by Mr. Godfrey: "there is no escaping the conclusion that a large vertical force (the shear of the beam) must pass through the tension rod." It must now be remembered that "shear" means a great many different things, according to circumstances. In reinforced concrete analysis, when a professor discovers a crack in a beam for which he can find no logical reason, he terms it either a shear crack or an inclined tension crack. Here, Mr. Godfrey means the sum of all the external forces acting on the beam to the left of the section considered. It is perhaps evident that this sum is simply and purely

*Concrete-Steel Construction (Der Eisenbetonbau); by Ernst Mörsch, translated by E. P. Goodrich. New York: Engineering News Publishing Co., 1909.

an imaginary quantity, introduced in beam calculations to express a certain condition having no reference to the nature of the beam itself. Whether or not this mathematical abstraction can be made to pass through any particular point except on paper, is very doubtful. The absurdity of the proposition becomes clear when we see this vertical force actually distributed over the section, uniformly or otherwise, to suit the fancy of the ambitious designer. The correct truth is that any section of a beam receives certain stresses in its own plane, and that, more particularly, a vertical section carries certain stresses, the sum of which stresses must be equal to the sum of all loads on one side of the section, assuming the loads to be vertical, and the reactions to be included in the loads. As to the distribution of these stresses, we know *a priori* nothing, but, when the material is known, we may under certain circumstances approximate the truth. Thus, in a composite beam, in which the one material is assumed to be without tensile resistance, and the other material is supposed to carry all tension, the conditions are entirely different from those existing in a steel beam. Mr. Godfrey's theory that this sum (not "force"), goes through the tension rod is too vague to be readily understood. The fact is that the vertical sum of surface stresses on the *concrete* section is equal to this "shear force," the concrete below the neutral axis being disregarded for the reasons explained in the argument to the second point. When, however, the beam has some bent rods, this is entirely changed, and it can be proved that: when the bars are bent to follow an equilibrium polygon for the external forces, including the reactions, the surface stresses on a concrete section as the one here considered become zero.* As this condition cannot exist under moving loads the value of the bent bars depends largely upon the ratio between the stationary and the moving loads.

As to the theory of continuous beams considered by Mr. Godfrey in items 6 and 7, we must admit that there can be no tension over the supports unless the beams are continuous. If now we use a tension reinforcement over the columns it seems reasonable to give the middle of the beam credit for a corresponding reduction in reinforcement, provided this reduction is otherwise consistent with the assumptions made.

The criticism offered in the ninth point with reference to T-sections is not verified by the writer's experience, nor is it consistent with economical design. The writer of this letter, and indeed, most other engineers, have considered the slab portion of the beam as effective in compression without experiencing any troubles when the structure was completed and used. The many structures with narrow beams would fail at once if it was actually necessary to provide concrete enough to develop the adhesion and shear stresses specified by Mr. Godfrey, in the concrete alone. But, when the ends are anchored in the next span as required by good engineering, and when the proper number of the bars are bent up, the sliding resistance of the ends alone is nearly sufficient to maintain the stability of the beam. The balance of the sliding resistance is furnished by the concrete of the stem, assisted by the transverse action of the stirrups. That there is such an action may readily be seen by theory alone; the same is shown by tests, see Mörsch p. 47.

In the tenth point, Mr. Godfrey proceeds to knock out the two only remaining props of the reinforced concrete theory, and his sledge hammers are (1) the uncertainty of the true value of the coefficient of elasticity for concrete, and (2) presence of initial stresses. Instead he recommends an "extremely simple" formula for bending, which is, unfortunately, conspicuous by its absence. It is not stated that this formula eliminates the influence of the initial stresses, which is, of course, impossible. That such a formula is, at the best, a special case of the usual straight-line formula, from which it may be derived by assuming a certain arbitrary value for the coefficient of elasticity, does not concern Mr. Godfrey. We have now seen that this proposed method does not eliminate the difficulties. It is well known that the straight-line formula is very simple to use, so that the only advantage gained by Mr. Godfrey seems to vanish. But even then, Mr. Godfrey deserves credit for calling attention to these initial stresses, which should never be disregarded. The fact is that the factor of safety used for all structures is invented for the particular purpose of taking care of all these unknown stresses. As the coefficients in the usual beam formulas are based upon results derived in part at least from tests on real floors, they do depend upon the unknown stresses as well as upon the so-called known stresses.

The twelfth point is correct in one respect: we cannot predict the deflections with certainty. It is, however, clear that the wide variation shown by Professor Lanza's two identical beams is due, not to a poor theory, but to causes connected with the beams, or the conditions surrounding the tests. The writer ventures to assert that identical beams will deflect the same amount under the same conditions. And here is where the great trouble arises: the concrete manufactured at the universities for the purpose of tests is not as well made, as uniform in quality, as the concrete turned out by average gang of laborers, especially where mixing machines are used. The many self-contradictory results obtained are due solely and entirely to this cause, as strikingly shown by the instance here cited.

In regard to the thirteenth point, it would be of interest to know how Mr. Godfrey proceeds with design of arches without using some kind of an elastic theory to find his equilibrium polygon. But aside from this, the elastic theory as commonly used is not correct. The arch does not stop at the beginning of the abutment, which in reality is an integral portion of the arch, unless hinges are actually introduced. On the other hand, cementing the blocks together does indeed change the stresses entirely, and a fixed arch, calculated as a two-hinged arch, but with solid connection to the abutments, would undoubtedly crack at once.

The fifteenth point is intended to put an end to our theories of hooped columns. That a very large number of engineers in America and abroad consider Considère's discovery one of the most beautiful contributions to the engineering science makes little difference in this connection, but should be noted for its own sake. But, unless actual tests should demonstrate beyond doubt that Considère, Mörsch, and many others have grossly misrepresented the facts, or made unbelievable mistakes, the writer shall continue to believe in hooped columns, and use them when convenient as he has done in the past. The tests quoted by Mr. Godfrey are strongly in favor of the theory, rather than otherwise, where details are given. It is not far from being a crime to space the hoops 12 ins. on centers in a 10½-in. column, as in Mr. Withey's tests; it is a direct confirmation of all Considère's statements that the Minneapolis column refused to act as a hooped column, because a 7-in. diameter and 4-in. spacing between the hoops does not constitute a hooped column. It is unnecessary to go into details regarding the column reinforced with longitudinal rods only, as no one at any time has claimed any carrying capacity for such columns in excess of the strength of the plain concrete, or even less.

Yours truly,

Alexis Saurbrey.

709 New England Bldg., Cleveland, O., April 2, 1910.

*The word "surface stresses" is used here to designate those stresses acting in the surface itself, as distinguished from those normal to the section.

The Passage of Pathogenic Bacteria Through Sand Filters.

Sir: When in Europe two years ago, my attention was called to some facts relating to the efficiency of sand filters for water purification in removing pathogenic bacteria, and a number of German articles were mentioned which contained experimental results relating thereto.

A water-supply engineer stands between the taxpayer, whose money he is to expend, and the chemist and bacteriologist, whose opinions and results he must accept in his desire to furnish the taxpayer with the best water at the least cost. When chemists and bacteriologists differ among themselves, the engineer, being compelled to assume a basis for his work, must use and act upon his own judgment and himself decide what basis he will adopt.

In a recent report,* I inserted the three paragraphs quoted below because it appeared to me that the evidence from various quarters harmonized sufficiently to require the engineer to take note of the possibility under some conditions of propagating pathogenic bacteria within filters. I was well aware of the consequences of such a statement, but as it could be coupled with another statement that a hypochlorite treatment efficiently and very economically destroys pathogenic bacteria before or after the water is passed through filters, there should be no disturbance whatever of public confidence in their use. Moreover, we can never nullify facts by ignoring them, and the sooner we recognize them and find means of correcting them, the better will be the result. The quotation follows:

"The longevity of typhoid bacilli is quite variable. If placed in distilled water their life is very short; when placed in polluted water or sewage, unless destroyed by other bacteria, it is much longer; and when enclosed in minute lumps of fecal matter, their life may continue indefinitely. It may continue for years, as typhoid bacilli have been found in a vigorous condition in privies that had received feces from typhoid patients two or three years before.

In the autumn of 1909, experiments were made in the rate of growth of typhoid bacilli in the water of Mille Lacs Lake and in the highly colored and highly nitrogenous water of its tributaries. The samples were taken on Aug. 25 and were sown, by Dr. Corbett, with 8,000 typhoid bacilli. On Aug. 27, after two days, the lake sample contained about 2,000,000 bacilli, and the sample of the affluents about 3,000,000 bacilli. On Aug. 31 these amounts were reduced to about 165,000 and 1,500,000, respectively, and on Sept. 3 to about 2,000 and 500,000, respectively. The water in the tributaries contained more dissolved organic matter than the lake, and this food material may be the cause of the greater development of the bacteria therein. This experiment further showed to what extent lake water might be a suitable culture medium for typhoid bacilli.

It has been demonstrated elsewhere that typhoid bacilli will multiply in and pass through water filters, if these contain sufficient nutriment in solution and provide other conditions for their propagation, and that they will not pass through the filter if such conditions do not exist."

*"Report of an Improved Water-Supply for the City of Minneapolis, Minn.," by Rudolph Hering, dated March 17, 1910.

It has occurred to me that a somewhat more specific statement might be desirable in the circle of those whose profession brings them in contact with questions relating to water supplies, and I send you, therefore, the following remarks which constitute some of the evidence upon which the engineer, as juror, should form his judgment. In the water supply for a community, we should take no chances. We must give the innocent members of it the benefit of every doubt and place their water supply above suspicion. And if there is an actual assertion of facts repeated in quite different quarters although opposed in some others, the engineer can do nothing else but guard his works, even against merely possible defects, so that no harm may be done in either case.

Results of German Experiments.

For a number of years, sanitarians have endeavored to ascertain how objectionable bacteria are destroyed by filters. Although Massachusetts, England and France have done a large amount of excellent work in throwing light upon this subject, Germany has also been active. As we are generally better acquainted with the results in the first mentioned countries, it may not be out of place at this time to call attention to some of the work that has been done in the last mentioned one.

As already pointed out by Hazen, the experiments of Fränkel and Piefke (1)* in 1890 indicated the fundamentals of water purification by sand filters. They proved that not alone may sand in mass hold back bacteria but that their retention is chiefly accomplished by the superficial cover (Schmutzhaut, Schmutzdecke, Schlammschicht) over the sand, consisting of very fine particles of mud and dead organic matter. They further proved that the velocity of filtration should not be over 100 m.m. per hour, if bacteria were to be held back. They found that the beginning and ending of a run were the dangerous times.

Filters becoming old permit bacteria to grow and increase within them (2) because sufficient nutriment accumulates in the pores to encourage their multiplication (3). Germany has recorded more investigations than other countries regarding house filters (Kleinfilter) for small quantities of water and they have materially assisted in throwing light upon the general subject.

W. Hesse (4) in 1885 experimented with sand, animal charcoal, compressed asbestos, cotton and cellulose. The latter two materials gave poor results, as bacteria came through very freely. Animal charcoal did better, as at least for the first two days no bacteria were in the effluent. Among those four materials, asbestos gave the best results. The bacteria which passed through the filters were not always the smallest ones. In fact, the latter were generally retained by adhesion. The larger bacteria, or those having active motile powers, generally passed through. Hesse found that some of the materials, including the sand of sand filters, sometimes caused a greater number of bacteria to be in the effluent than were in the influent.

Plagge (5) in 1886 found that after eight days some common asbestos house filters passed from 100 to 1,000 times the number of bacteria that were in the influent. Kübler (6) in 1890 found that after eight days even a Pasteur-Chamberlain filter, if not cleaned, could deliver more bacteria into the effluent than were in the raw water.

W. Pfeffer (7, 8) tested the sensibility of bacteria resulting from chemical stimulants, particularly as to their powers of locomotion and chemotactic movements.

Hesse (9) and Chlopin and Tamman (10) in 1903 proved by experiments that bacteria become less active the greater the water pressure under which they operate, but that pressures of even 500 atmospheres apparently did not destroy them.

Kirchner (11) in 1893 added typhoid and cholera bacilli with bouillon to the water passed through a filter, and, finding them in the effluent, therefore condemned all filters. Gruber (12) in 1893 and Schöfer (13) in 1893 opposed this somewhat radical view and demonstrated that the penetration (Durchwachsen) of typhoid and cholera bacilli occurred only when the water contained

*The numerals refer to the appended list of authorities quoted.—Ed.

sufficient dissolved organic matter (Nährlösung). They maintained further that the demand for nutriment differed considerably between pathogenic and common water bacteria.

Gruber proved that water bacteria find conditions for their propagation in the pores of filters even when fairly good river water is filtered, which has also been observed elsewhere. He further found that such water is too poor a nutriment (viel zu schlechte Nährflüssigkeit) for typhoid and cholera germs, and asserts that their propagation in such water is "impossible." The conclusion now pretty generally accepted is that typhoid bacilli gradually and sometimes rapidly die and disappear in unpolluted river waters, and even in some polluted waters (U. S. Supreme Court decision in Chicago Drainage Canal Case). This view is held and acted upon in many cities in both Europe and America.

Schöfer's experiments with typhoid and cholera bacilli were first made with water that was sterile when turned upon the filter. Then no bacilli appeared in the effluent. But as soon as he added dissolved organic matter, these bacilli appeared, because conditions were offered for propagation. When the organic matter was washed out and the water was once more sterile, the bacilli again disappeared. Schöfer also showed that the temperature had much to do with the passage of bacteria. In room temperature they appeared in the effluent within a few days. When they were applied with cold water their first appearance was not until after several weeks.

Lübbert (14) in 1891 anticipated some of the above statements in showing that pathogenic bacilli did not pass through filters when the applied river water was fairly good and contained but little dissolved organic matter.

PENETRATION OF BACTERIA INTO FINE CAPILLARIES.—Hofstädter (15) in 1905 conducted an interesting series of experiments to determine the conditions of penetration of bacteria into and through fine capillaries. He selected pure cultures of species which easily multiply and could be readily detected. They were chiefly B. prodigiosus, B. fluorescens longus, hay bacilli and yellow and orange cocci. The capillary tubes ranged from about 0.001 to 0.01 m.m. in diameter. Great care was taken to get definite, clear and reliable results. A special make of glass was used and, after sufficient practice with an assistant, the tubes were carefully drawn so that they were both sterile and of desired diameter, the latter being accurately determined. The main conclusions were:

The time required for the bacteria to enter or penetrate the capillaries, was found to depend greatly upon the particular kind of bacteria, upon their size and motility, and upon the diameter of the capillary tubes.

The penetration of bacteria into fine capillaries containing nutriment was limited only by the diameter of the tube, and did not vary much with the size of the bacteria smaller than the diameter.

A penetration into capillaries filled with liquid nutriment did not take place if their diameters were less than 0.0016 to 0.0019 m.m., but was considerable if the diameters were over 0.005 m.m.

A penetration in the capillaries without liquid nutriment did not take place with diameters less than 0.0016 to 0.0023 m.m.

Under a pressure up to three atmospheres, bacteria did not enter capillaries into which they would not themselves have entered without pressure.

The above results confirm the view now pretty generally held by engineers, at least in Europe, that the removal of bacteria from water or sewage while passing through a sand filter is not caused wholly by a screening effect when passing through fine pores or even through a slimy film consisting of minute capillaries, but also and perhaps chiefly by surface attraction. In large-grained sewage filters the latter is clearly the case, and surface attraction is not only the chief, but probably the sole, cause of removal of the fine suspended and colloidal matters from sewage which is accomplished by the use of the Dibden and Travis plates.

Conclusions.

The general conclusion which the water-supply engineer must draw from these and many other results is that properly devised and operated sand filters, when the raw water is not much polluted, will safely remove pathogenic bacteria. There appears to be sufficient evidence, however, that with a sufficient quantity of nutriment dissolved in the water, pathogenic bacteria not only pass through filters, but their number may actually increase within them. With these facts in mind, double filtration has proposed as a safeguard, and has been practiced in Altona and Bremen in Germany for a number of years. The engineer must, therefore, be on his guard when advising sand filters for domestic consumption, and still more so when advising filters for the purification of sewage, as they receive a large amount of dissolved bacterial nutriment which may cause pathogenic bacteria to be nurtured and propagated in filters. He must also take account of the fact that when screened or settled sewage is discharged into and sufficiently diluted by unpolluted waters, or waters containing a small amount of organic matter in solution, pathogenic bacteria will, on the other hand, be deprived of favorable conditions for life and will therefore perish.

Fortunately we have now a remedy against the danger of escaping pathogenic bacteria by their direct destruction with hypochlorite of calcium and sodium, which can be economically applied in connection with the filtration of water supplies, and also for sewage purification after the suspended organic matter has been substantially removed by filters or otherwise.

Rudolph Hering, M. Am. Soc. C. E.

New York City, April 21, 1910.

AUTHORITIES QUOTED.

1. Fränkel u. Piefke, "Versuche über die Leistungen der Sandfiltration." "Zeitschrift f. Hygiene," 1890, Bd. 8.
2. v. Esmarch, E., "Ueber kleinste Bakterien und das Durchwachsen von Filtern." "Zentralblatt f. Bakteriologie," 1902, Bd. 32.
3. Hesse, G., "Beiträge zur Herstellung von Nährböden und Bakterienzüchtung." "Zeitschrift f. Hygiene," 1904, Bd. 46.
4. Hesse, W., "Über Wasserfiltration." "Deutsche Medizinische Wochenschrift," 1885.
5. Plagge, Tageblatt der 59. "Versammlung deutscher Naturforscher und Aerzte," 1886, S. 323.
6. Kübler, "Untersuchung über die Brauchbarkeit der Filtres sans pression, Système Chamberland-Pasteur." "Zeitschrift f. Hygiene," 1890, Bd. 8.
7. Pfeffer, W., "Lokomotorische Richtungsbewegungen durch chemische Reize." "Untersuchungen aus dem Botanischen Institut Tübingen," Bd. 1.
8. Pfeffer, W., "Ueber chemotaktische Bewegungen von Bakterien, Flagellaten und Volvozineen." "Untersuchungen aus dem Botanischen Institut Tübingen," Bd. 2.
9. Hesse, W., "Über Wasserfiltration." "Zeitschrift f. Hygiene," Bd. 1, S. 178.
10. Chlopin u. Tamman, "Ueber den Einfluss hoher Drucke auf Mikro-organismen." "Zeitschrift f. Hygiene," 1903, Bd. 45.
11. Kirchner, M., "Untersuchungen über die Brauchbarkeit der Berkefeld-Filter aus gebr. Infusorienerde." "Zeitschrift f. Hygiene," Bd. 14 u. 15, 1893.
12. Gruber, M. "Gesichtspunkte für die Prüfund und Beurteilung von Wasserfiltern." "Zentralblatt f. Bakteriologie," 1893, Bd. 14.
13. Schöfer, H. "Ueber das Verhaltea von pathogenen Keimen in Kleinfiltern." "Zentralblatt f. Bakterio'ogie," 1893, Bd. 14.
14. Lübbert, "Pharmazeutische Zentralhalle," 1891, Nr. 39 u. 40.
15. E. Hofstädter, "Das Eindringen von Bacterien in feinste Kapillaren," "Archiv für Hygiene," 1905.

Notes and Queries.

In the description of the brick water tower at the Cook County Poor Farm, on p. 340, of our issue of March 24, it should have been stated that the water tower and the chimney adjacent, which is the tallest chimney in Cook County, were built by the M. W. Kellogg Co., of New York City.

Mr. S. Heyward, an assistant engineer of the Atlantic Coast Line R. R., corrects, as follows, the item in our issue of April 14, p. 447, on the wreck of a passenger train at De Leon Springs, Fla.:

In the first place, calling it a derailment gives the impression of defective track. The cause was a sideswipe. A light engine, running in same direction as the passenger train, was backing into a pass track to clear the main line, but failed to get in the clear in time to prevent being struck. Both engines left the track. Our doctor, who was at the wreck, informed me that there were no deaths and that only ten persons were injured, none seriously.

It is noteworthy that this corrected account of the accident adds another to the list of a half-dozen or more wrecks involving light engines already reported for this month.

Some Views on the Chicago Harbor Problem.

A report on the Chicago harbor problem and its solution, made by a committee of the Western Society of Engineers, was published (in condensed form) in our issue of March 3. We are now able to give some abstract of the discussion which followed the presentation of this report, and have commented upon the matter in our editorial columns.

Col. C. McD. Townsend, U. S. Engineers.—When the majority of the wharves and slips were constructed on the Chicago River, there were few if any vessels on the Great Lakes over 200 ft. in length, and 12 ft. draft. The construction of the locks at Sault Ste. Marie and the deepening of the channels connecting the Great Lakes have created a revolution in vessel construction. In 1890 a vessel was built 310 ft. in length; by 1895 the length had increased to 380 ft., by 1900 to 474 ft., in 1906 over 600 ft. And at the present time there are built and contracted for 19 vessels of 600 ft. in length, capable of carrying a cargo of 12,000 tons each.

In 1895 the freight passing the "Soo" was all in vessels less than 400 ft. in length; in 1903, 40% of the freight was carried in vessels exceeding that length; and in 1908, 74% (45% being in vessels over 500 ft. long). This has resulted not only from the building of large vessels, but also the withdrawal of the smaller from trade.

A vessel 200 ft. long has comparatively little difficulty in navigating the Chicago River, even in a moderate current. But when 75% of the commerce of the lakes is in vessels exceeding 400 ft. in length, it is another story. With a discharge of 10,000 cu. ft. in the Chicago River, it will be a physical impossibility for a modern lake freighter to proceed from the mouth of the river to the Chicago Drainage Canal, or to enter any of the numerous slips in its vicinity. In my opinion, the widening and deepening of the Chicago River to more than 16 ft. above the Forks for purposes of navigation is a waste of public funds. If the Chicago River is ever to regain its commercial importance, it will have to be by a system of wharves near the river mouth, and distribution of freight by lighters.

The value of barge navigation is not appreciated in this country as it should be. The lighter is one of the great causes of New York's supremacy. According to the census report for 1906, there was a traffic by water in New York Harbor of over 113,000,000 tons, of which about 33,000,000 tons was in the coast trade, 25,000,000 tons in foreign trade, and 55,000,000 tons in harbor traffic. That is, there was a barge and lighter traffic far in excess of the combined rail and water commerce of Chicago.

I regret that in the very able paper on the "Development of Commercial Ports," in the report of the Chicago Harbor Commission, a more detailed description of Cuxhaven, the auxiliary port to Hamburg, was not given. Hamburg had to face a somewhat similar problem to that which confronts Chicago at the present day. The enormous increase in draft in the transatlantic steamship had to be met, and that city's solution of the problem was an outer harbor and the lighter.

A deep waterway through a city does not necessarily add to its prosperity. Cities are created where deep waterways stop, and where the cargoes from the vessel are transferred to other means of transportation. The 60,000,000 tons of freight traffic which passes Detroit annually does not benefit that city, but it passes through the Detroit River without seriously disturbing the traffic within the city limits. A ship canal through the heart of Chicago, ending at Joliet or Grafton, might be a very good thing for Joliet or Grafton, but would be an insufferable nuisance to the city of Chicago and of little value in its commercial development. To pay for the construction of a ship canal, it must transport a considerable amount of freight. If we assume that a ship canal through Chicago would develop the freight that existed at the Soo in 1895, before the completion of the Canadian and Poe locks, there would be required to carry that freight 16,793 vessels during a season of navigation, or one vessel would pass through Chicago, on an average, every 20 minutes. What would happen to the enormous land traffic across its 26 bridges under such conditions?

Mr. John M. Ewen, M. Am. Soc. C. E. (Chairman of the Harbor Commission).—The Harbor Commission in its report submitted to the City Council on March 1, 1909, recommended construction by the city of piers north of the mouth of the Chicago River for the accommodation of passenger and package freight and the fruit lines. It further recommended the enactment of enabling legislation necessary to promote that end.

The Council Committee on Harbors, Wharves and Bridges arrived at the conclusion that the city's financial situation was not such as to warrant it in undertaking the work of dock development on the basis of immediate municipal ownership. Therefore the committee entered into negotiations with certain promoters looking to dock development under a franchise arrangement. I am not necessarily opposed to a franchise plan, but it does seem to me that the negotiations with these interests are not likely to lead anywhere. No other serious competitor for a dock franchise grant has thus far appeared upon the scene. There appears to be little likelihood, therefore, of the early starting of a dock enterprise through city activity, either on the basis of city construction and ownership or under a franchise arrangement.

In view of this situation the practical thing to do, it seemed to me, was to make the Sanitary District Board the harbor authority for Chicago and give it the power to go ahead with the work of dock development. This course, provided the necessary enabling legislation can be secured, means speedy action as opposed to a long period of delay and inactivity if the city is to be made the agency for dock development. The Sanitary District has at its disposal the funds necessary for undertaking and carrying on the work. It has a good business and engineering organization. As a harbor authority it would correspond somewhat to the harbor trusts which have control of harbor and dock development in the principal cities of Great Britain.

Mr. Isham Randolph, M. Am. Soc. C. E. (Consulting Engineer for the Chicago Sanitary District).—My own views were concisely expressed for the use of our chief state executive in the following statement: Chicago is losing its share of the water-borne commerce because it has no adequate harbor. Chicago has no money now, or yet in definite prospect, with which to build a harbor. Private interests know this, and are tempting the city officials to turn over to them its rights in waters and submerged lands to it belonging or by it controlled.

Chicago has bartered its commercial birthright for visions of beauty in which parks, shrubbery, lagoons, drives, pagodas, triumphal arches, and all the rest of the gorgeous pageant usurp the waters in which ships

should lay alongside wharves and warehouses equipped with every modern convenience for interchange of freight with cars on contiguous tracks; which tracks are there for use upon equal terms by every road entering the city. Chicago needs a harbor for the lake freighters that are plying, and for the river boats that will ply between her port and New Orleans when the lakes-to-the-gulf waterway is an accomplished fact.

There is a way open for Chicago to get a harbor which will be her own, and cramped by no private interest, and that the best harbor on the lakes. First, repeal the act which robbed commerce of its right and gave all of the lake front to the park commissions. Then, if you will, pass a new bill which will give the South Park Commission all of the lake front between 42d St. and the Indiana state line which does not belong to individuals or corporations. Let commerce have one-seventh of Chicago's water front. This done, impose upon the Sanitary District of Chicago the duty of creating such a harbor as the second greatest city in America ought to have.

But why impose this duty upon the Sanitary District of Chicago? Because that district is a creation of the state, and the state may and can enlarge the scope of its duties. Because that district has taxing powers which do not have to be enlarged to enable it to carry on the work of harbor building. Because the limit of bonded indebtedness of that district has not been reached; therefore, because the District has the financial ability to plan, prosecute and complete the work. Because the District is officered by citizens of Chicago whose interests are bound up in the welfare of the city. Because the trustees of the Sanitary District have an enviable record for honest administration and successful accomplishment.

Because Chicago needs its harbor at the earliest date that it can be created, and the Sanitary District is a going concern, fully officered and equipped for conducting and accomplishing large public works. Because, if the day comes when a wise public policy demands a transfer of authority from the organization known as the Sanitary District of Chicago, to the organization known as the city of Chicago, there will be no vested private or corporate rights to intervene and prevent the transfer.

Mr. J. W. Mabbs.—Building wharves at the mouth of the river would not produce a harbor but would merely increase the wharf facilities. The plan I propose is to build a breakwater from near Evanston south to beyond the Calumet River. This can be made from the broken rock on the banks of the drainage canal. There is sufficient to build a wall of this description the entire length of the city, some 25 miles or more. This rock can be taken by water transportation and dumped until it comes within a short distance of the surface of the water, when dump cars can be used to complete it.

Figuring this embankment at 50 cts. per cu. yd., which should be ample for all contingencies, a sea wall or breakwater could be built 21½ miles along the lake shore of this city for about $6,000,000 or $8,000,000. Of course this does not include any wharves or any connecting tunnels, which undoubtedly would be an expensive part of the proposition.

Slips or wharves ¼-mile long could be located on the shore side of the breakwater, and connected to the shore by means of tunnels; these tunnels to be connected by a longitudinal tunnel, from which the cars could be lifted to the wharves by means of elevators, so that the freight could be transferred directly from the railroad system to the shipping, and vice versa. It would also become necessary, no doubt, to have grain elevators and coal transfer arrangements on these wharves, so that coal and grain could be quickly handled.

The breakwater could be built in sections, as funds permit and circumstances demand. I estimate that a large portion of the breakwater, one system of tunnels, and sufficient wharves for Chicago's present needs could be built for $10,000,000, and not over 50% of this amount would have to be expended before the city would begin to reap the benefit. The plan could be extended and enlarged from time to time to such an extent that in 100 years the expenditure might reach $200,000,000.

Mr. Mershon.—If the same amount of money were used to construct an estuary leading out to the lake somewhere between 16th and 25th Sts., 200 ft. wide, and tangent to the bend in the south fork of the Chicago River, an inland harbor might be constructed that would be a great deal better than any lake front harbor.

Mr. H. B. Ford.—Milwaukee has a better harbor than Chicago. The non-line boat, or tramp boat, that carries ore, grain, and coal, will be chartered for a cargo of coal to Milwaukee in preference to Chicago, everything else being equal, because the boat can deliver the cargo there and get away more economically. The modern steamer costs from $6 to $8 an hour to operate. That makes about $190 for 24 hours, and the only way it can offset this cost is by running and earning money. Therefore, if a boat comes to Chicago with a cargo of coal and is 24 hours here getting rid of it, it is out nearly $200. The owner will not send the boat here again if he can get a cargo anywhere else.

The large carriers of 550 to 625 ft. in length and 50 to 60 ft. wide, that carry from 10,000 to 13,000 net tons in bulk, have no reason at present to come to Chicago, because they are built for a special purpose, which is to run between an ore dock and South Chicago, the steel works at Gary, and Indiana Harbor. They do not carry package freight, and when they take coal it is because they are unable to get ore and they take coal to a modern dock. The boats that will come to Chicago will be somewhere from 3,500 to 9,000 tons.

Mr. L. E. Cooley*, M. Am. Soc. C. E.—The situation has not changed greatly since I wrote "The Lakes to the Gulf Waterway" in 1891, at which time I discussed at great length the whole harbor subject of Chicago and its future. What I then predicted has come to pass, that we would uproot the commerce we then enjoyed at Chicago, but that we could not transplant it. It has always appeared to me that there were two factors in this problem. First and foremost is the sanitation of the city. There is a special factor in this question; that is, the waterway to the Gulf, and the provisions it is necessary to make in this city for its sanitation will provide for its harbor and for its commerce. If we had involved only the matter of commerce by lake and its relation to rail commerce, all the discussion would be germane, but in view of this other factor, which I believe will prove to be the greatest factor in the problem, we must of necessity produce a great channel to Lake Michigan. Not two channels, but one channel, because one channel is a ship canal; two or more channels are ditches. When that great channel is produced, in my judgment, the harbor becomes a mere incident to it, and it serves all three purposes—not only of a ship canal but of a harbor—for a harbor, as well as for sanitation, and in the best possible relation to the population of this city.

When we have solved the sanitary question properly and sufficiently, and have produced what is necessary in connection with the waterway from the Gulf to Lake Michigan, the harbor problem itself becomes comparatively cheap, much less expensive than any of the solutions that I have seen proposed.

I have indulged my dreams, as many of you are now doing, in regard to the future of Chicago, but I began a generation ago, and have had some of the dreams come true, and I expect more of them will be made good. My dream in this connection is something like this: That we are to produce a great waterway to the Gulf, fed eventually by all the surplus waters of the Great Lakes, and that this channel is to extend behind us down through the State of Illinois. Along that channel are to be located manufacturing industries, and it will be a continuous harbor and an industrial region all the way. It will occur to you from a sanitary standpoint that the only rational and cheap way to take care of all the sewage products which an enormous population will produce, is for it to locate along this channel.

Mr. B. J. Mullaney (Secretary to the Mayor).—To say that the Sanitary District would be, financially and otherwise, better able than the city to handle dock building and harbor improvement is the merest subterfuge. The Sanitary District is already bonded, we are told, up to within $4,000,000 or less, of its limit. And the Calumet channel, which is to cost more than twice $4,000,000, has not yet been dug.

During the last regular session of the General Assembly, there was objection to giving the city means of issuing more bonds because it would raise taxes. That objection became so potent that the Legislature made a law prohibiting bond issues by cities without submitting all proposed bond issues to direct vote of the people. The law does not apply to the Sanitary District. After giving the District dock-building powers, is it intended to let it pile up a bonded debt on the people of Chicago (who pay practically all of the money that goes to the District) without the people having a word to say about it?

There is a law question, too, that must be faced. Does transfer of the city's harbor jurisdiction, in part, to the Sanitary District, the bonded debt of which covers practically the same property as the bonded debt of Chicago, amount to an evasion of the constitutional inhibition against any municipality going in debt beyond 5% of its assessed valuation?

No acute demand has arisen for legislation authorizing a headlong plunge into the "construction, ownership and operation of docks, wharves, warehouses, elevators, railway terminals and all necessary appurtenances," at great expense to the people. The lake cities which, we are told, have taken away the shipping rightfully belonging to Chicago, have had no advantage over Chicago which could have been, or can yet be, offset by public ownership of docks, wharves, and all the rest of it. Those cities have simply cooperated with the national river and harbor improvement service—have given that service a chance to help them—in keeping their harbors unobstructed. Private enterprise has done the rest—supplied the docks and other harbor facilities, as it always will. Nowhere in America has it been demonstrated that public ownership can do better work than private ownership.

*The first Chief Engineer of the Chicago Sanitary District, 1891.

The Discharge of Sewage Into the Hudson River.

A bill is pending in the New York legislature which would empower the State Health Commissioner to stop cities from discharging sewage into running streams. A protest against the bill has been made by Palmer C. Ricketts, M. Am. Soc. C. E., head of the Rensselaer Polytechnic Institute, and is printed in the "Troy Times," of April 15. We reprint portions as follows:

First. The bill gives too much power to the Commissioner of Health without a proper chance for appeal.

That this is not a theoretical objection is proved by the fact that the present Commissioner of Health, in a letter dated Nov. 28, 1905, refused to permit the city of Troy to build any new sewers or extend old ones until plans for a separate system of sewers and a sewage treatment plant had been provided.

I quote from this letter:

It is the present policy of this department to secure in situations which render them desirable and feasible the accomplishments of two results: First, the stopping of the *increase of population* without immediate reference to the elimination of existing pollution excepting in places where the latter becomes essential and advisable.

The Commissioner had no power to compel the city to establish this treatment plant and it did not do it. It would have cost the city about three million dollars. Under the state Constitution it can spend only about $600,000 before reaching its debt limit.

Second—Was it believed in giving this order that if the house sewage of cities situated on a large river like the Hudson be treated before its discharge into the river the water becomes pure?

This is entirely untrue. A large river is a sewer. If you remove from it the house sewage it still remains a sewer. The storm water discharged from the city streets and other places along its banks makes it one and makes it unfit for drinking purposes for human beings unless it be first filtered. If a drastic law is to be passed it should rather be to the effect that every municipality must filter any surface water it may use for drinking purposes, no matter whether it be obtained from a river or elsewhere, in order that reasonable safety be insured.

Why compel a city to filter or treat its sewage at great expense before its discharge into a large river when the water must in any case be filtered before it can be used for a water supply, and when such filtration does in any case insure practical purity? Witness the case of the Albany filter plant, in which the Hudson River water is filtered and the water made nearly perfectly pure.

Third—The discharge of the sewage of cities into large bodies of water is common everywhere. It is recognized as a perfectly proper method of disposal by eminent engineers and by experts on pure water supply. The State Board of Health of Massachusetts, composed of eight eminent citizens of the state, has been studying the question of pure water supply for more than a quarter of a century. Its investigations are classic. It stands easily at the head of State Boards of Health in this country. In 1908 it was ordered by the Legislature to examine the condition of the Merrimac River and report whether "conditions injurious to the public health existed on this river," and if so, to report a plan for their removal.

The Merrimac River case is similar to the Hudson River case. Its low water discharge at Lowell and Lawrence is about the same as that of the Hudson at Troy and Albany. There are more than 250,000 inhabitants in the cities and villages above Lawrence which discharge their sewage without treatment into the Merrimac. Lowell has about 112,000 inhabitants, and is situated about eleven miles above Lawrence, on the Merrimac. Its crude sewage is discharged into the river. Lawrence uses the water of the Merrimac for its water supply after filtering it, just as Albany uses the water of the Hudson River after filtering it. After an investigation of more than a year in duration the Massachusetts Board of Health reported that by proper regulation "the river may be kept for many years—perhaps for generations—free from danger."

Fourth—It is a matter of common knowledge that almost every city in this country situated on a large river discharges its sewage, without first treating it, into the river. This method of disposal is quite common abroad. Abroad the sewage is generally screened before the discharge takes place.

Fifth—Deaths from typhoid fever are lamentable. So are all deaths. It cannot be proved that most of the deaths from typhoid fever are due to water-borne germs. Everyone knows that with unlimited means many lives now sacrificed might be prolonged. This is as true of other diseases as of typhoid fever. In 1909 in New York State ten times as many died of pulmonary tuberculosis as of typhoid fever. Why not, from a public health point of view, instead of making Troy spend three millions of dollars to leave the Hudson still a sewer, make

expend this money toward the eradication of tuberculosis?

Sixth—As regards its method of sewage disposal the city of Troy is not at all on the defensive. Its sewage should be screened, but that is all. No one should be permitted to attempt to compel it to bear an extraordinary and unwarranted burden, a burden absolutely and constitutionally impossible for it to bear, because it is doing what nearly every city in every civilized country situated as it is situated, is doing. It should not be throttled by either fanaticism or ignorance. On the contrary, they are on the defensive who propose and would have compelled the city to inaugurate a futile scheme, which would have left the Hudson for all practical purposes in the same condition as it was before.

The Massachusetts State Board of Health Report on a Mechanical Filter Plant for Lynn, Mass.

The city of Lynn, Mass., after long discussion over methods of purifying its water supply proposes to adopt a system of mechanical filtration. The general scheme proposed was submitted to the State Board of Health on Jan. 26, and that body on April 7 made a reply objecting to the plan. The full text of the Board's reply is as follows:

To the Public Water Board of the City of Lynn.

The State Board of Health received from you on Jan. 26, 1910, a communication stating that the City Government of Lynn on Jan. 24, 1910, approved and endorsed the recommendations of your board relative to the treatment and purification of the public water supply of the city by the installation of a mechanical filtration system.

Your report of Jan. 21, 1910, contains the following recommendations:

With the distinct understanding that the best chemical-mechanical plant must for safety always be under the care of a competent expert, that daily analyses must be made of the water, the best safeguards and checks against unskilled handling provided and our storage facilities utilized to their fullest extent, the following plan combining long storage and purification by chemical-mechanical means is now recommended. In this plan it is proposed not only to filter all of the water but to improve the storage conditions by the installation of pumps at Montrose, on the Saugus River and at Hawkes Pond, discharging into the northern arm of Walden Pond, thus not only getting additional storage and the opportunity of taking water from Saugus River at any time but making it impossible, in any practicable way, for water to reach the filters until it has been stored for a long time.

If this general plan is approved by the council and the state board of health, as required by the law, detailed plans will be prepared and submitted to the council and the state board for final examination and approval, as the act also required.

Without plans of the work and method of treatment it is not practicable to make accurate statements of the results; but from experience and experiments made elsewhere it is probable that the cost of maintaining an efficient plant will be enough more than the cost of maintaining good slow sand filters to make the entire cost of construction and maintenance of the chemical-mechanical filters greater than that of the slow sand filters.

In the removal of color the chemical-mechanical filter has some advantage, but the result from either process with Lynn water would probably be entirely satisfactory. In the removal of disagreeable tastes and odors, a chemical-mechanical filter would not be as efficient as a slow sand filter. With such tastes and odors as have been experienced during the past year, the proposed process might be satisfactory; but the increasing amount of Saugus River water to be added to the reservoirs is likely to increase the growth of organisms which produce disagreeable tastes and odors to such an extent that mechanical filters will not remove them.

The efficiency in removal of bacteria of the best chemical-mechanical filters is not as high or as steady as of the best slow sand filters.

Complaints are made of excessive corrosion of iron pipes and copper tanks in which is used filtered water from well managed chemical-mechanical filters, which effect appears to be most serious with soft dark waters, like those of Lynn. This is thought to be due to the increase in carbonic acid in such waters due to filtration with coagulants.

With these results we have reason to expect active corrosion of steam boilers and water containing so much iron rust as to be very objectionable for domestic use.

We find no such general improvement in the health of the community from using the best regulated mechanical filters as when good slow sand filters have been used.

While purification by chemical-mechanical filters remains in its present experimental condition, with very objectionable results unremoved, we are unable to advise the adoption by the city of Lynn.

By order of the Board.

Boston, April 7, 1910.

Relative Efficiency of the Day-Labor and Contract Systems of Doing Municipal Work.

In our issue of Jan. 27, we reprinted a valuable paper by Mr. Harrison P. Eddy, M. Am. Soc. C. E., Boston, Mass., giving the results of studies which he made for the Boston Finance Commission regarding the day-labor and contract systems of doing city work. That paper was read before the American Association for the Advancement of Science. A paper covering somewhat the same ground is printed in the January number of the Journal of the Association of Engineering Societies, accompanied by some interesting discussion. A number of those who took part in the discussion expressed themselves in favor of the day-labor system.

Mr. Charles R. Gow, speaking from experience with both systems, stated that inefficiency of labor occurs just as often in contract as in day-labor work wherever "inefficient supervision and a faulty system of control exists." He proceeded as follows:

In the first place, the rate of wages paid for foremen and superintendents in municipal and most government work, is as a rule, I think, less than is paid by the large contracting concerns doing the same work on the same scale, and that would mean, of course, that a much less efficient class of foremen would be carried by the cities than by the contractors. We have found from experience that some foremen are cheap at $10 a day, while others who might be willing to work at from $2.50 to $3 a day, would be very expensive. As an illustration, I once worked as superintendent of a large contracting concern in New York. They had previously done railroad work, and they were engaged at the time on the construction of one of the large subway sections there, and brought on a lot of these foremen to handle that work. And the first criticism I made after looking over the work was that they did not have a sufficient number of competent and experienced foremen. I was told to hire any foremen I knew who were suitable for the work, but when I mentioned the fact that we should probably have to pay $150 a month for such foremen as I had in mind, the president of the company threw up his hands. After considerable argument he finally agreed to allow me to engage two such men as I wanted at that salary. The first of these men who happened to appear on the work was put in the place of a $3 man. And his first act was to discharge six men out of the gang, and in his first day's work the result was an increase in output of 25%. And this increase in output, as I remember it, represented a value of something like $35 to the contractor. That would illustrate in a way what I mean when I say that the high-priced foreman is oftentimes cheap in the end.

The cities, of course, establish a fixed rate for their foremen as a rule. There is no promotion by merit, and there are seldom any questions asked as to the ability of the foreman, provided he comes with the proper credentials from the civil service or other department. Of course, the average laborer will do no more work than he is required to do, whether he is working for the city or for a contractor. And unless he has competent supervision the results cannot be expected from him. The political aspect of city labor was pretty clearly dealt with by Mr. Eddy. Of course, its demoralizing effect is unquestioned. It was in order to correct the evils of political control that the civil service system was inaugurated, and yet to my mind that is even a greater evil as regards labor in efficiency than political control. When, some years ago, I was acting as superintendent for the Boston Transit Commission, in charge of their contract labor, we had some six hundred men employed. That was on the original subway, doing some special work where it was adjacent to buildings, or in localities where it was feared the contractors might lead the commission into difficulties. We were obliged under the law to procure all the labor from the civil service list. And the most difficult feature of the whole undertaking was to secure a gang of men that we could do anything with at all. The trouble seems to come in this way. The good men, the efficient men, are seldom out of work for any great length of time. The value of their services is well recognized by contractors, and as soon as they finish up one job they secure other work, if there is work being done. Consequently they don't take the trouble to register with the civil service commission and wait their turn before they are certified for employment. The majority of the men who do register with the civil service commission are men who can't find employment in any other way and simply look upon the city as a good asylum from which to obtain an easy living. The result, as we found it, was that if we wanted 25 men to start a piece of work, we would make requistion for 100, and out of that 100 probably 50 would appear with high standing collars and patent leather shoes, and some of them on crutches or otherwise disabled. And we would be expected to select from that crowd a gang of men to go down 25 or 30 ft. below the surface of the ground to brace trenches and excavate in wet and difficult ground. I can readily understand where the city departments may be seriously handicapped on that account and where a really conscientious official would have serious difficulty in obtaining a gang of men that would be suitable for his needs.

The next evil that suggests itself to me is the influence of labor unions. The labor vote, of course, is of such consequence that it can't be ignored by political office-holders if they expect to continue in office. And the result is that labor councils have been allowed wide latitude in dictating the details of labor administration. It is one of the avowed principles of the labor unions at the present time to so regulate the output of men as to make positions for the largest number of men possible. And they consider it perfectly legitimate to so cut down the output of one man as to make room for a second one doing the same work. Of course where this is allowed to prevail, as I believe it is largely in the city employ, it can't be expected that efficient service can be maintained.

Then there is the question of discharging men in the city employ. Now that they are under the protection of the civil service, it has become a matter of considerable difficulty for a foreman to get rid of an inefficient man. And I can readily see where all these things combined can tend to raise the price, as Mr. Eddy has shown. The matter of employing citizen labor is very fine in sentiment, but it hardly makes for economy. The contractors found long ago that the available supply of English-speaking labor was practically exhausted, that is, the supply of competent labor. And they were obliged to turn to foreign labor, not so much as a matter of economy, as a matter of necessity. My own experience is that we pay practically the same rates of wages to the competent foreigners that we do to equally competent Irishmen or Americans. And while we would much prefer to have the English-speaking man to the foreigner, we find it impossible to obtain a sufficient number of competent men. And, as a matter of fact, the Italian labor at the present time is becoming scarce. The better class of Italian laborers to-day can command and receive $2 a day, when business is good, for common labor. We pay some of them who are skilled a little beyond the average as high as $3 a day. We pay a minimum wage in our company of 17½ cts. an hour, and an average for common labor of probably about $2.10, which is not a serious handicap to day labor as a matter of competition.

I am inclined to take issue with Mr. Eddy as to the possibility of day work being done better than contract work. My experience and observation lead me to a different conclusion. I have noticed that where day labor is in vogue, as a rule there is no inspection, and where there is any conscientious endeavor to do the work cheaply, it is carried to the same extreme that a contractor is apt to carry his work in doing it cheaply. I have in mind an instance I noticed a few years ago in one of the cities nearby where bids were asked for the construction of a covered waterway, a brook channel, I think it was. And for some reason all the bids were rejected and the work was done by day labor. In that case there was an inspector on the work who appeared to me to be a little more ambitious to hustle the work along and to do it cheaply than even the foreman himself. Most of his energies were given to pushing the work. On that particular piece of work there was a concrete arch, very flat, as I remember it, and not more than 12 ins. in thickness. And at the time I noticed the work they were concreting this arch and imbedding in it field stone as thick as they could get them and still have them come within the limits of the sections. Now, so far as I know, no serious trouble has occurred from that type of construction, but I rather imagine that if a contractor suggested that to an inspector or an engineer he would be told a few things. There are several other cases I have in mind where contracts have been called off and bids rejected and the work subsequently done by day labor and the engineers or inspectors, having the contract price in mind as an upset price which they must not exceed, have stretched their consciences materially to keep within the limits under the disadvantageous conditions they were put to by the labor situation and expense.

As a general thing, in letting contracts, the disadvantages that Mr. Eddy referred to, and which I admit are considerable, could largely be overcome if the engineers would show a little more courage oftentimes in rejecting low bids and the bids of incompetent parties, and insist, as far as they are able to do so, on awarding the work to competent parties at what would be a fair and living price. We all of us make mistakes in our bids. We often overlook important items. You understand, of course, that the working engineer has had months, perhaps, to think over the problem and to think over the obstacles and the difficulties to be encountered, while the contractor is obliged to form his judgment in a few days, and oftentimes the best of con-

tractors make serious mistakes in estimating the work, and consequently bid ridiculously low. Of course, there is a certain spirit among contractors as well as other business men that makes them feel like standing up and taking their medicine under such circumstances. And oftentimes they would appreciate a suggestion from the engineer that he would like to have them retire under the circumstances and allow him to award the contract to a higher bidder. It is not impossible to find out by a proper investigation just what the ability of the contractor is and whether the work in question is beyond the limit of his ability. It seems to me that it would be perfectly proper, and should almost be deemed necessary under the circumstances I have outlined, to advise the awarding of the bid to some other contractor. And if this were done in all cases I think that the difficulties that arise out of contract work in some cases could be largely overcome.

The question of day-labor versus contract work will probably never be entirely settled. It is probably generally admitted that day-work must cost more than contract work. But there is a question whether or not, in a certain measure, the public does not wish to accept the conditions as a concession to policy and sentiment, provided the difference is not excessive.

Mr. Adams called attention to the great difficulty experienced in making reasonable comparisons of cost work in different cities. In Arlington, Mass., for instance, expenses due to office force were included in the cost of sewer work, as well as the cost of preliminary plans. Most cities, he stated, omit such items. In contrast, many cities merely report lump sums.

The plan followed by Somerville, Mass., in reporting cost of sewers, was considered by Mr. Adams to be "almost ideal." The items given are as follows:

Cost, location of sewer, the material excavated, the name of the contractor (they do nearly all their work by contract), the average cut, the size of the sewer and sub-drain, the amount of rock excavated, the price per cubic yard of rock, the number of manholes, the average cost of the manholes, the number of inlets and the unit price of these various items, and, in addition, other things, such as the cost of inspection; and some cities include also the cost of other engineering work besides inspection and the cost of materials when the city supplies them, and also the amount of the assessments that are levied. This system is followed more or less, mostly less, by the other cities.

Mr. Edgar S. Dorr remarked that:

When politics gets into the contract system and interferes with and demoralizes the inspecting force, then most of the advantages of the contract system will disappear. The costs will be increased by inefficient and venal inspectors, and not only that, but the quality of the work will be demoralized. The result will be that the work will not be economical and will also be bad.

Mr. Henry Manley, of Boston, suggested that a considerable saving in the contract cost of sewers might be affected if a city proposing to construct a large number of short scattered sections of sewers in a given year would take some pains to advertise the work so that it could be let in groups. Mr. Eddy endorsed this proposition, and remarked that in one year the city of Boston let some 250 contracts, which might have been so arranged geographically as to have been included in 50 groups, with a group cost of from $10,000 to $20,000. Had this plan been followed, the contractor might have got together and operated contract plants and gangs with considerable saving in cost.

Mr. Charles R. Felton, of Brockton, Mass., stated that this city formerly did all its work by contract labor and that he was a strong advocate of that system when the city changed to the day-labor plan. He thought he had possibly changed his mind a little since then. He continued:

It is still an open question, and yet I think that in Brockton, under our conditions, it would be difficult for a contractor to do our work as cheaply as we are now doing it by day labor and pay the same wages. Mr. Eddy's chief points for the contract system, and the only points, are the incentive, which is of tremendous importance, and the fact that the city is forced to pay higher wages than the contractor under present conditions. Under our conditions, it would be impossible, probably, to let contracts without a clause stipulating that the contractor should pay $2.25 per day for a minimum wage. Our system there, as shown in those figures, seems to be very close to what we pay; that is, $1.20 per ft. I should think, is very close to what it would add up. We sometimes run our sewers, in fact, two years in succession, at $1.43 and $1.42 per ft., including all materials. It is true in all cases that everything is in there, that is, every dollar that is spent is in there. And paying the same rate of wages, I doubt whether a contractor would make much profit at that cost. Our conditions are practically ideal. We run the same organization entirely through the year, starting in the moment the frost is out of the ground and never stopping until the ground is frozen up again, when we close down entirely, and employ practically new men the next year, except the foreman, whom we maintain the year around. Our work is almost uniform in quantity, from 3½ to 5 miles every year. There are, perhaps, some indirect benefits in the day-labor system. Mr. Eddy has covered most of them. It is possible in the day-labor system to give employment to a large number of citizens. This may decrease disbursements in the poor department—probably does to a great extent. And the money that is paid out is circulated almost entirely within the city's limits; none of it is taken out of town. In relation to the day-labor system, it seems to me that the opportunities for graft are less, the temptations are less than would be the case in the contract system. There is no opportunity for collusion excepting in the purchase of materials, and as to the matter of good work, I am almost inclined to agree with Mr. Gow that the character of the work obtained under the contract system is even better than under the day-labor system. I don't think poor work, as a rule, is due to fraud or a desire for fraud, but is almost all due to carelessness or ignorance.

Mr. Branch, of Quincy, Mass., put himself on record as a convert to the day-labor system, after having had some experience with it. He said, in part:

My own whole experience leads me to believe that with a proper organization, as good an organization as we can get in Quincy, we can do work as cheaply by day-labor as by contract; that is, that work costs no more when done by day-labor than when done by a contractor, if the contractor gets a reasonable profit. A careful study of the cost to the contractor of work done under these unit prices per cubic yard, etc., showed that a reasonable price wasn't always paid to him. The costs of certain sewers done by day-labor seemed to be very large for certain grades of work. And I made a study of the force accounts of contractors on similar work. I found one street where there was no water, a perfectly dry street, where, of course, the contractor or the city either would have to anticipate no difficulty in construction, but the work actually cost the contractor for items which I knew, and I don't pretend to know all the items of cost to the contractor, but the items I was sure of cost the contractor two and one-half times what he thought they would. I found over a period of some three years, looking at sewers where there was a water depth of from 10 to 20 ft. in trenches, a number of instances, in fact, in nearly every instance, that the force account showed the cost to the contractor was one and three-quarters to three times the price he received for the work. And I found that the work lost in the same proportion. There was work done by the city by day-labor which was done at a considerably lower price than the lowest price made by any contractor. That was the easy work, the kind the contractor would make money on. And I also found that when either contractor or city gang got on a difficult proposition the work went slower. And I did not find that very many contractors' foremen handled the work very much better than the city's foremen did. For several years practically all of our work was done by day-labor. The cost seemed to be so much larger than some of our contracts that the commissioners thought it would be possible to make a change and to go back to the contract system. And the last year that we did any considerable amount of work on construction we let half the work that year, perhaps, by contract. And I noticed that the unit prices were nearly double what they were five years before. Contractors had grown wise and were not making such ridiculously low bids on work.

Some Los Angeles Aqueduct Costs.

PROGRESSIVE REDUCTION OF TUNNEL COST.—Figures of costs on the Elizabeth Tunnel, recently sent us by Mr. J. B. Lippincott, Asst. Chief Engineer of the Los Angeles Aqueduct, indicate the large influence of efficiency and training of the working force upon the unit cost of work. The Elizabeth Tunnel was begun in the fall of 1907, from both south and north portal, later with the temporary assistance of a shaft 3,000 ft. from the north portal. At present both headings are over 8,000 ft. from their respective portals, and, as the shaft is now not used except for ventilation, the great length of haul in the tunnel might be expected to result in increased cost per foot compared with the early stages of the work. But this is not the case; on the contrary, Mr. Lippincott says, the tunnel has been driven at *a cheaper rate during the past five months than the average of the entire tunnel* since work was started. This is wholly due to the experience gained, and the improvement of the organization of the work.

These figures are summarized in Table I. The totals in this table indicate that during the five months in question the cost per foot was only a trifle over $30, as against an average of over $39 for the whole tunnel to date, and against an advance estimate of $46.25. Also, as will be seen from the notes, there has been a considerable gain over the estimate of time required, promising to complete the tunnel in about 80% of the estimated construction period.

Table II., giving details of the character of rock encountered in the two headings during the same five months to which the costs refer, shows that the improvement apparent even within the five-month period is not due to better ground, but shows up in spite of unfavorable ground, as for example in the North Heading figures for February, 1910.

MUNICIPAL WORK PROVES FAR CHEAPER THAN CONTRACT.—An excellent comparison of some Aqueduct cost figures with the prices bid by contractors for the same work is given in the "Pacific Outlook" (Los Angeles, Cal.), of April 2, 1910. This issue contains an article by Mr. Lippincott traversing a defamation of municipal day labor which appeared recently in an Eastern contract journal. He shows that on the Jawbone Division of the Los Angeles Aqueduct the city work has accomplished a saving of $13 per foot of tunnel, and nearly $4 per foot of conduit, as compared with cost under the lowest bid. This saving will total nearly a mil-

TABLE I.—ELIZABETH TUNNEL WORKING COSTS, OCTOBER, 1909—FEBRUARY, 1910.

[Not including percentage for Equipment, Buildings or Pipe Lines.]

(Work done by three 8-hr. shifts, 18 men each, at each heading.)

Month.	NORTH HEADING / SOUTH HEADING	Progress, ft. Excavn.	Progress, ft. Timbrg.	Powder, lbs. per ft.	Costs per foot Excavn.	Costs per foot Timbrg.*	Costs per foot Admin. & housing.	Costs per foot Total.
October, 1909		547	547	20.3	$23.80	$6.33	$1.53	$31.66
		413	159	27.2	$30.20	$3.79	$3.55	$35.35
November, 1909		471	471	17.5	24.65	5.86	1.91	32.42
		378	85	38.1	33.91	5.25	4.62	39.62
December, 1909		476	476	12.8	23.11	6.99	1.56	31.66
		480	50	35.9	29.96	7.72	3.62	34.42
January, 1910		481	481	14.1	24.64	7.04	1.85	33.53
		515	104	33.7	28.83	6.33	2.30	32.45
February, 1910		529	529	15.1	21.94	5.60	2.25	$29.79
		516	188	28.3	25.73	4.43	1.67	$29.07
Average from beginning of work to March 1, 1910								$39.32
Estimate, average cost of excavated and timbered tunnel								$46.25

*Per foot of timbering; enters into total after being reduced to cost per foot of excavation.

NOTES: Total length of tunnel, 26,860 ft. = 5.09 mi.; Slope, 1:1,000. Estimated time required for construction, 56 months. Progress for February, 1910, both headings, 1,045 ft. = 37.3 ft. per day. This is the best joint monthly record, being an average of 6.2 ft. per shift at each heading.

Total progress to March, 1, 1910:

North heading	8,647 ft.
South heading	8,616 ft.
Both headings	17,263 ft.

Percentage of total excavation, 64%.
Percentage of estimated time, 52%.
Section Quantities: Net area after lining, 90 sq. ft.
Excavation, normal timbered, per ft., 5.02 cu. yds.
normal untimbered, per ft. 4.18 cu. yds.

ABLE II.—CHARACTER OF GROUND, BY 10-DAY PERIODS, ELIZABETH TUNNEL.

NORTH HEADING:		
t.	1 to 31.—Wet ground, requiring timbering	547 ft.
ov.	1 " 30.—Wet ground, requiring timbering	471 "
c.	1 " 10.—Bad ground, heavy, talc seamed	172 "
c.	11 " 20.—Dangerous ground, requiring heavy and close timbers	163 "
c.	21 " 31.—Wet ground, requiring timbering	141 "
n.	1 " 10.—Better ground, nearly solid	127 "
n.	11 " 20.—Medium granite	172 "
n.	21 " 31.—Hard granite	182 "
b.	1 " 28.—Wet, heavy ground, requiring close timbering	529 "
SOUTH HEADING:		
t.	1 to 10.—Altered granite	126 ft.
t.	11 " 20.—Rotten, seamy granite, strong flow of water	144 "
t.	21 " 31.—Varying from rotten to hard granite	143 "
v.	1 " 10.—Very hard, with feldspar crystals	128 "
v.	11 " 20.—Hard quartz granite	120 "
v.	21 " 30.—Hard quartz granite	130 "
c.	1 " 10.—Hard quartz granite	143 "
c.	11 " 20.—Hard granite	161 "
c.	20 " 31.—Granite [Hard, 140 ft.; medium, 36 ft.]	176 "
n.	1 " 10.—Medium granite	141 "
n.	11 " 20. [Medium hard granite	95 "
	[Gray granite	75 "
	[with water courses and cavities, flow about 7 miners inches.	
n.	21 " 31.—Medium hard granite	204 "
b.	1 " 10.—Medium hard granite	193 "
b.	11 " 28.—Very hard granite	323 "

TABLE III.—COST COMPARISON BETWEEN CONTRACT AND CITY WORK ON JAWBONE DIVISION OF LOS ANGELES AQUEDUCT.

(Costs per foot.)

TUNNEL. (Length, 63,798 ft.)		
Cost under Lowest Bid:		
Contractor's bid	$31.11	
Materials to be furnished by city	3.32	
Engineering & Insp., incl. in city costs	1.08	
		$35.51
Cost under City Work (61,515 ft. excavated, 33,805 ft. lined):		
Excav. & lining (incl. engrg. & insp.)	$19.50	
Maintenance and operation	.68	
Equipment (Pipe & telephone lines, buildings, roads, etc.)	2.20*	
		$22.38
Saving, per foot of tunnel		$13.13
CONDUIT. (Length, 39,223 ft.)		
Cost under Lowest Bid:		
Excavation	$6.48	
Lining and cover	6.80	
Materials to be furnished by city	2.97	
Engineering & Insp., incl. in city costs	1.08	
		$17.33
Cost under City Work (33,868 ft. excavated, 16,100 ft. lined):		
Excav. & lining (incl. engrg. & insp.)	$10.90	
Maintenance and operation	.38	
Equipment	2.20*	
		$13.48
Saving, per foot of conduit		$3.85

*Cost $227,000, which has been distributed uniformly over whole length of division, 103,021 ft. No salvage counted.

llion dollars for the division when completed, about one-third of the whole cost at the lowest bidder's price. The figures are summarized in Table III.

But for a true comparison the saving should be shown even larger than given in this table, for not only has salvage on the equipment been disregarded in the above figuring, but some extra work is included in the city's costs, though the contractor would have obtained extra pay for this. Further, the costs of the work are decreasing progressively, in the way illustrated in the first part of this article, and a greater saving will therefore be shown on the work yet to be done.

A very important advantage of the municipal management plan of working is that there is easy opportunity to make changes in location or design, while under a contract this would be very difficult. Quite extensive changes have been made in the Los Angeles Aqueduct plans after work was started. Thus, the first location showed 28 miles of tunnel, whereas the line as now being built has 43 miles of tunnel. As the progress of excavation shows up the character of the material, changes in design often become desirable, which are readily made under city management.

It is proper to add that Mr. Lippincott restricts his argument to large pieces of work. On such, he says, a non-political management should always be able to secure as capable men and as high-grade machinery as any contractor. This point, we may remark, is amply shown by the Panama Canal construction work.

One Month's Operation of the Cleveland, Ohio, Ry. Under Three-Cent Fares.

The final settlement of the street-railway troubles in Cleveland, Ohio, by the passing of a franchise ordinance which was ratified at a referendum election on Feb. 17, was discussed in Engineering News, March 10. By the plans which went into effect Feb. 19, a 3-ct. cash fare, with 1-ct. for a transfer, was imposed for eight months. At the end of this trial period, if the excess of earnings over operating expenses, plus certain depreciation and interest allowances fails to meet certain requirements, stated in the ordinance, then a higher rate of fares may be permitted.

The report of the Street Railway Commissioner for the operations during March were presented to the City Council on April 11 and from the report we have abstracted the most important figures:

MILEAGE—		
Total passenger-car mileage		2,055,563
Total revenue-car mileage		2,072,141
Total car mileage		2,079,881
INCOME ACCOUNT—		Cts. per car mile.
Gross earnings from operation	$475,749.50	22.96
Operating expenses	321,181.86	15.50
Net earnings from operation	$154,567.64	7.48
Miscellaneous income	1,743.56	.03
Gross income, less operating expenses	$156,311.20	7.54
Taxes	26,641.84	1.28
Income, less operating expenses and taxes	$129,669.36	6.26
Interest	110,788.42	5.35
Surplus	$18,880.94	.91

The items of the above table are explained, in part, by the following figures:

GROSS EARNINGS FROM OPERATION—		Cts. per car mile.
Car earnings:		
Passengers	$462,734.24	22.33
Less rebates to other companies	1,245.72	.06
Net from passengers	$461,488.52	22.27
Chartered cars	1,305.52	.06
Freight and express	3,209.47	.16
Mail	1,156.58	.06
Passes	2,734.50	.13
Newspapers	1,333.33	.06
Total car earnings	$471,227.92	22.74
Advertising and miscellaneous earnings	4,521.58	.22
Gross earnings from operations	$475,749.50	22.96
MISCELLANEOUS INCOME—		Cts. per car mile.
Interest on deposits	$1,272.17	.06
Interest on bills receivable	25.00	....
Rent of real estate not used in operation	446.39	.02
Total miscellaneous income	$1,743.56	.08
OPERATING EXPENSES—		
Maintenance—2,072,141 miles at 4 cts.		$82,885.64
Operating expenses—2,072,141 mi. at 11½ cts.		238,296.22
Total		$321,181.86
TAXES—		Cts. per car mile.
On real and personal property	$20,935.60	1.00
On earnings (to state)	4,774.93	.23
U. S. corporation tax	931.91	.05
Total taxes	$26,641.84	1.28
INTEREST—		
On funded debt	$33,962.50	1.64
On floating debt	3,447.92	.17
On Cleveland Ry. stock	73,378.00	3.54
Total interest	*$110,788.42	5.35

(*Interest on neutral Street Railway investment not included in above.)

TESTS OF ROAD-BINDING MATERIALS on a road in actual use are being made by the Ohio State Highway Department under direction of Mr. James C. Wonders, Commissioner. The road selected is Nelson Ave., in the outskirts of Columbus, accessible by the Columbus, New Albany & Johnstown Interurban Ry. with a 20-minute ride from the city. Sections of this road 16 ft. wide and 400 ft. long have been treated with the processes offered by different manufacturers, and 17 different sections are now in place. These sections were laid last summer, and the road has been in use since then, carrying a heavy traffic. A report upon these experiments has just been issued by the Highway Department as "Bulletin No. 12," but is chiefly devoted to the method of laying the different road-making materials. It is the intention of the Department to issue additional bulletins in the future, giving the relative wearing qualities of the different roadway materials.

A Portable Stone Crushing and Concrete Mixing Plant for Street Railway Work.

In the construction and reconstruction of street railway lines the economical preparing and placing of the concrete base or the broken stone ballast is one of the important points to be considered. In reconstruction, use is sometimes made of stone or old concrete removed from the work, and in such case the most economical method usually is to crush the stone and prepare the concrete on the line of the work. Portable concrete mixing plants of different kinds have been used for work of this kind in Chicago and elsewhere, but a combined rock-crushing and concrete mixing plant is a novel type of equipment which has been built for the Metropolitan Street Ry. Co., of Kansas City, Mo. This railway is doing a large amount of reconstruction, and expects to effect a considerable decrease in cost by the use of this portable plant.

The entire plant is mounted on a steel flat car 40 ft. 6 ins. long and 8 ft. 2 ins. wide over the sills, mounted on two steel-frame trucks with 4½-ft. wheelbase (trucks of 6-ft. wheelbase were proposed). The side and end sills are 12-in. channels, while the two center sills and two intermediate sills are 6-in. channels which rest on the bolsters and on 6-in. I-beams framed between the side sills. On one side, the center sill and intermediate sill are continuous, but on the other side they are interrupted at three points in order to leave necessary openings under the machinery. Each bolster is of box section, composed of two 8-in. channels (set back to back) with top and bottom plates ½ × 10 ins. Upon the steel frame is a double floor of planking. The maximum height, when all parts are extended, is 16 ft. 3 ins. above the top of the rails. This can be reduced to 13 ft. 4 ins. when it is necessary on account of low overhead clearances, such as are sometimes encountered on bridges, etc. This allows 8 ins. clearance space between the highest point of the apparatus and the lowest position of the trolley wire.

The principal equipment consists of (1) a 25 H.P., 500-550-volt motor running at 850 r.p.m.; (2) two bucket elevators, with 18 ft. and 14 ft. centers; (3) a Gates crusher, and (4) a Chain Belt concrete mixer of the drum type, of 12 cu. ft. capacity per batch. The crushing machinery is supported on heavy timber framework. The total weight of the equipment (exclusive of the timbering and the car) will be approximately 25,000 lbs.

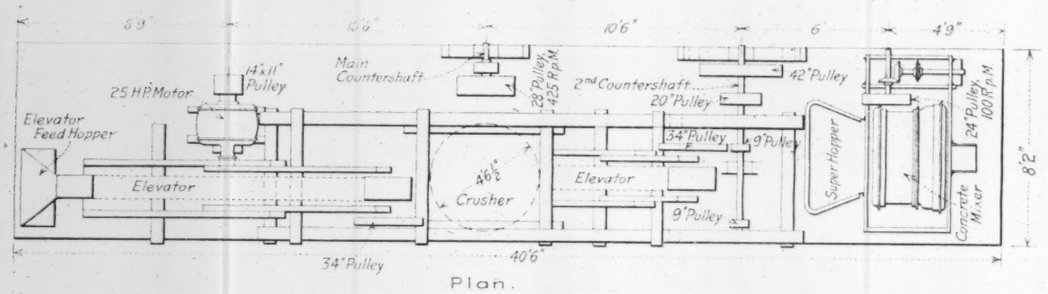
The elevators have a timber framework, and each is built in two sections. These sections are so arranged that when extended the maximum height mentioned is attained, and when lowered they have the proper clearance under the wires; it is stated that it will not be necessary to lower these very often. The boots of the elevators are carried beneath the level of the floor of the car in such a manner that they can be fed directly from the floor. The lowest point of the elevators is 8 ins. above the top of the rails, giving ample clearance. The elevator belt is 12 ins. wide and the buckets are each 11 × 9 ins., made of No. 16 metal. The crusher is mounted at the middle of the car and is supported by heavy timbering above an opening in the floor. This opening allows the removal of the bottom plate of the crusher, and also provides space for the boot of one of the elevators. The crusher is supplied with right angle drive. The produce of the crusher will average about 1¾-in. stone.

The concrete mixer is mounted at one end of the car. The motor is mounted near the other end, and is belted to the main countershaft of the crusher, the crusher being driven by gearing. The shaft carries also a pulley for a belt to another countershaft from which are run the belts driving the concrete mixer and the two elevators. Current for the motor will be taken from the trolley wire by means of a rod and hook. A suitable starting box will be mounted near the motor.

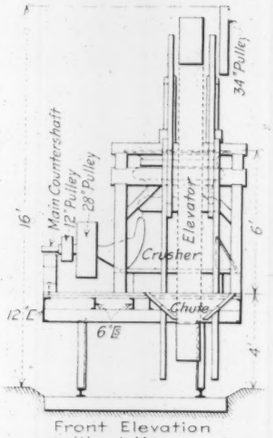
In operation, the stone or old concrete will be thrown onto the platform near the end of the car and will be fed into the hopper of the first

elevator. This will feed the crusher. The broken stone from the crusher will fall into the boot of the second elevator, which will discharge the stone into a hopper bin above the concrete mixer. This bin has one spout which leads to the concrete mixer and a second to the side of the car, so that the stone may be used for ballast or for concrete. After the concrete is mixed it is discharged by a chute at the end of the car, and is delivered directly onto the roadbed or carried away in wheelbarrows, as may be desired. The cement for the concrete will be fed from a platform built above the mixer.

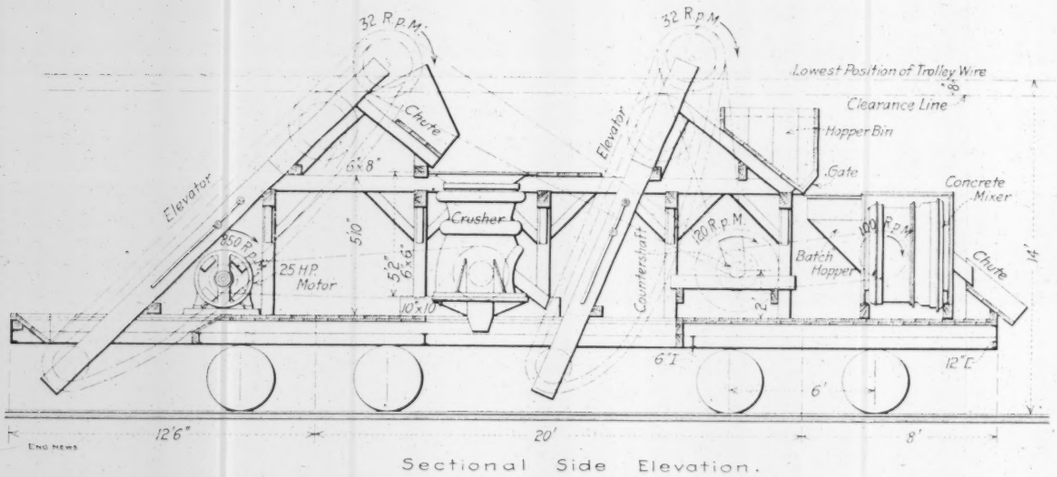
A particular feature is the small number of men required in the operation of the plant. One man can oversee the entire crushing plant, so that when ballast is being supplied only this one man is needed on the car. When concrete is being mixed, two additional men are needed;



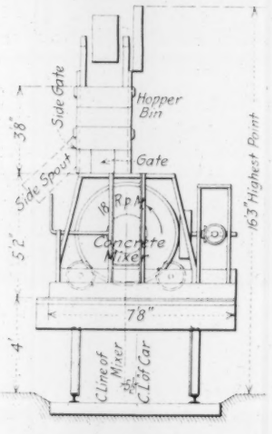
Plan.



Front Elevation without Motor.



Sectional Side Elevation.



Rear Elevation.

PORTABLE STONE CRUSHING AND CONCRETE MIXING PLANT; METROPOLITAN STREET RAILWAY CO., KANSAS CITY, MO.

one to feed cement and stone, and one to add the water and discharge the concrete.

Two advantages claimed for this machine as compared with others which have been used are as follows: (1) the entire plant is mounted upon a single car; (2) there are no conveyors or other parts which have to be taken apart every time the plant is moved. The entire plant was designed by the Allis-Chalmers Co., of Milwaukee, Wis., which supplied the equipment complete. The steel car, with the timber framing to carry the machinery, was built by the railway company.

A HOTEL FIRE AT CINCINNATI, OHIO, April 24, shortly before midnight, destroyed the building, the Hotel Thoma, a six-story wooden structure, and caused the death of two guests and one employee.

A conflagration at Lake Charles, La., April 23, swept over 20 blocks in the business and residential sections of the city and destroyed several hundred buildings. About 2,000 persons were left homeless. The principal building destroyed was the recently constructed courthouse and city hall.

TWO COAL MINE EXPLOSIONS last week killed a total of about 55 men and heavily damaged the mines. The first explosion occurred at nine o'clock at night on April 20 in the Mulga mine of the Birmingham Iron & Coal Co. near Birmingham, Ala. The two shafts of the mine, about 300 ft. apart, but connected underground, were both wrecked by the explosion, whose flame rose to a considerable height from the mouth of shaft No. 1. No fire followed the explosion and both fans were kept in operation. In spite of this, the black damp made it impossible for rescuers to enter the mine for some hours. About 40 miners were entombed by the explosion and reports of April 22 give the number of bodies recovered up to that time as 26.

The second explosion took place at 9:45 p. m., April 21, in the mine of the Youghiogheny & Ohio Coal Co., at Amsterdam, Ohio. The interior of the mine and the tipple were wrecked. A gang of 25 machine men were at work in the mine at the time but seven of them were rescued alive immediately after the explosion. The bodies of the remaining 18 were recovered later by men with oxygen helmets.

A CONSTRUCTION TRAIN WAS WRECKED on the Transcontinental Ry., of Canada, at Coocoocache, Champlain District, Que., April 17. The accident is variously reported as the collapse of a trestle, the caving of an embankment across the shallow end of a lake and a landslip in a rock cut. Reports agree, however, that several cars of the train were wrecked and that from four to ten men were killed.

AN EMERGENCY HIGH-PRESSURE WATER-SUPPLY system for Jacksonville, Ga., was put in operation early in 1910. Two electric motor-driven pumps with a capacity of 2,500 gals. per min. each deliver water through about five miles of 20 to 8-in. mains laid in the principal business district of the city. Jacksonville now has an estimated population of 65,000. Mr. R. N. Ellis is Chief Engineer of the Board of Bond Trustees, which has charge of the municipal water, electric lighting and sewerage systems of Jacksonville.

A CONCRETE DAM at Fertile, Minn., was washed out by the floods of the first week in April. A press dispatch in the Duluth "Tribune" says:

> The concrete dam built last fall, at a cost of $6,000, by Konkel & Hoss, to furnish power for their flour mill, was practically washed out by the high water. The foundations were not sunk low enough, as the water was going under the dam before it gave way.

FAULTY OPERATION OF THE MECHANICAL water-filtration plant at Burlington, Vt., is held responsible by Dr. C. F. Dalton, Health Officer of that city, for an outbreak of typhoid fever that occurred during September and October, 1909. Of 25 cases of typhoid fever during the year 1909, 21 occurred in September, October and November. There were four deaths from typhoid during the whole year, in an estimated population of 22,000, thus giving a death rate of 18 per 10,000. In his annual report for 1909, Dr. Dalton says that as soon as the faulty operation of the plant became known and was remedied,

> the infectious bacilli at once disappeared from the city water and the progress of the disease was arrested. This circumstance was not without a beneficial effect, as it served to show conclusively that the filter, properly operated, is an absolute safeguard against the infection of typhoid fever.

DAMAGES FOR A TYPHOID-INFECTED MILK-SUPPLY, to the extent of £500 ($2,430) were awarded not long ago in the "Civil Court of the Liverpool Assizes" (England). According to an interesting summary of the contentions on both sides of the lawsuit, published in London "Public Health" for January, 1910, the damages were based on "breach of an implied warranty under the Sale of Goods Act, 1893, that certain milk supplied was reasonably fit for consumption." A case of typhoid fever occurred on a dairy farm from which 25 different households were supplied with milk. Typhoid fever subsequently developed in 8 of these 25 houses. The typhoid cases were distributed through a number of different districts, with nothing in common but the milk-supply. Altogether some 200 adults were supplied with the milk in question, of whom 13, or 6.5%, were infected; while of 42 children supplied with the milk, 11, or 26%, were infected. The typhoid case in question was removed to a hospital for a period of some five weeks, but on pressure was allowed to return to the farm. The infection appears to have occurred after this return, and there also appear to have been several distinct infections. The evidence tending to show that this case was responsible for the typhoid outbreak appeared to have been strongly confirmed by the fact that subsequent to the return of the patient to the farm, first the farmer himself and then his son died from typhoid fever; while subsequently a servant who came to the farm later on also contracted the disease. The straits to which the defendants were put in the case, as well as the antiquated notions relating to typhoid infection which still find so-called experts to voice them in England, are shown by the attempts that were made to prove that the typhoid outbreak was due either to "sewer gas" or to aerial infection. Each of these theories was based on the occurrence of a number of cases of typhoid fever which had occurred prior to the out-

reak in question, at a small place on the seashore omewhere between a half-mile and a mile distant from he school in which was located the typhoid patient who igured in the damage suit. It seems that this school as connected with the sewerage system of the village question. It was claimed by the defendants that yphoid germs might have passed through the sewer from he village to the school, and particular stress was aid upon the fact that "an old drain passed under the lining-room of the school." The evidence showed, how-ver, that the drain in question, according to our con-emporary,

as covered by 8 ins. of macadam, 6 ins. of concrete, nd 1 in. of cement, and on this a floor of wood blocks et in bitumen was placed, thus rendering the floor quite mpervious to gas.

The aerial-infection theory had even weaker grounds or its support. It was a simple assertion that the oreshore about the sewer outlet of the village in ques-ion was polluted, and that typhoid germs might have een conveyed through the air for the three-quarters of mile between the foreshore and the school. Another lmost equally weak theory that was advanced by the efendants was that the sewage of the village infected ussel-beds, and that persons handling and consuming ussels from these beds had been infected.

THE ZEPPELIN rigid dirigible balloon of the German rmy was wrecked near Limburg, Prussia, April 25, dur-ng a wind storm. The airship was trying to make a re-turn trip from Cologne to Homburg (near Frankfurt), ut was forced to descend at Limburg because of shortage f gas. Soldiers had held the balloon safely through a ormy night and the gas bags had been properly refilled hen a sudden squall tore it from its moorings in spite of he work of two companies of infantry, it is reported. fter 30 minutes the airship dropped near Weilburg and he aluminum frame was demolished. No one was aboard uring the runaway trip.

A dirigible balloon, being used by the British army t Farnborough, England, was caught in a squall on April 25 as it was leaving its sheds. The framework was broken up and the gas bags were ripped to pieces.

THE RIVER AND HARBOR BILL, which passed the House of Representatives on Feb. 15 carrying appropria-ions of $42,558,000, was added to by the Senate Com-mittee so that, as reported to the Senate, it carried appropriations of $52,566,000. After an active debate n the Senate, chiefly notable for an emphatic condemna-ion of the bill by Senator Burton, long the Chairman of he Rivers and Harbors Committee in the House, the bill was passed by the Senate, as reported, on April 19.

A SMALL OUTBREAK OF TYPHOID FEVER at Winnipeg, Man., believed to be due to an infected dupli-ate water-supply which had been surreptitiously con-nected with the city supply, was reported in the "Ameri-an Journal of Public Health" for February, 1910, by Dr. Alex. J. Douglas, Medical Health Officer of Winnipeg. In October and November, 1908, a total of 26 men work-ing in the yards of the Canadian Pacific Railway Co. at Winnipeg came down with typhoid fever, and of these hree died. We quote from Dr. Douglas, as follows:

The C. P. R. yards are furnished with two sets of water mains; one of these contains water from the do-mestic supply of the city, which, derived from a series of artesian wells driven in rock, is of great purity. The water from this source is used by the company as a drinking supply for its employees and for filling the drinking water tanks of its coaches. The other set of mains carries water drawn from the Red River—a highly polluted stream—and pumped by the city high-pressure station for fire purposes through a restricted area. This river water is utilized for filling locomotive and station-ary boilers and is employed on account of being much softer than the domestic supply. The pipes carrying these two waters ramify extensively throughout the yards and the various buildings within them, and in some places are situated close together.

On Nov. 18, after a great many samples had been tested with negative results, water was obtained from a certain drinking tap from which it was possible to obtain bacillus coli in every instance. This organism is never found in the domestic supply of Winnipeg but always is present in Red River water. The building from which the suspicious samples were obtained was one of the places where the two sets of pipes were close together, and a careful examination revealed that a con-nection existed between them. The man in charge of the building (a gasometer house) admitted that he had connected the two early in October in order that should the high-pressure supply for any reason fail, an inci-dent that had once occurred owing to a break down at the pumping station, he would be able to fill his boilers from the domestic mains without loss of time.

When the connection between the two systems was found the course of events was very evident. Domestic water is forced through the mains at a pressure of be-tween 40 and 50 lbs. per sq. in., the high-pressure river water at anything between 150 to 300 lbs. When these two waters met the river water forced the other back up its own mains and replaced it there for a considerable dis-tance. Individuals using water from this line of pipe supposedly containing artesian well water were really drinking water from the Red River into which all the sewage of Winnipeg is discharged. It is to be noted that, with one exception, the affected persons had never been near the gasometer house at all, they obtained their water at a considerable distance from it.

The existence of this connection was definitely estab-lished on Nov. 19, when it was at once abolished. Cases of typhoid continued to arise until Nov. 30, which was the last.

AN EXHIBIT HALL FOR SAFETY DEVICES is to be opened in the Engineering Societies' Building, 29 West 39th St., New York City, by the American Museum of Safety. No charge will be made for space, but any exhibit offered must receive the approval of a board made up of Prof. F. R. Hutton and Messrs. Philip T. Dodge, Charles Kirchhoff, T. C. Martin and William H. Tolman. Any devices intended for the prevention of accidents will be eligible for exhibition.

A BILL TO ENCOURAGE INDUSTRIAL EDUCATION, in agriculture, trades, industries and home economics was introduced in the Senate by Senator Dolliver, of Iowa, Jan. 5. It is reported that at a recent hearing on the bill (Senate Document 4675) it was supported by representatives of the American Federation of Labor. The bill provides for the appropriation of $5,000,000 an-nually for "the maintenance of instruction in the trades and industries and home economics and agriculture in public schools of secondary grade"; $4,000,000 annually for "the maintenance of instruction in agriculture and home economics in state district agricultural schools of secondary grade"; $1,000,000 annually for the mainte-nance of branch agricultural experiment stations at sec-ondary agricultural schools; and $1,000,000 for main-tenance of instruction in the trades, industries, agricul-ture and home economics in state and territorial normal schools.

In general, the funds above noted for public secondary and state normal schools are to be allotted to the states and territories in proportion to population as shown by the 1910 census. Each state is required to establish one secondary agricultural school and one branch experi-ment station for each group of 5 to 15 counties, to ap-propriate, for the annual maintenance of the stations, a sum equal to its allotment for this purpose, and to pay the cost of necessary lands and buildings of secondary and normal schools, together with the cost of instruction in other general studies to make "well-rounded courses."

PRIZES FOR ESSAYS ON ECONOMIC SUBJECTS, amounting to $2,000, are offered by a committee of which Prof. J. Laurence Laughlin, of the University of Chicago, is Chairman. The essays are to be presented to the committee before June 1, 1911. A circular giving the subjects and conditions of the competition may be obtained by addressing Prof. Laughlin.

A PRIZE OF $4,000 for a paper on some electrical sub-ject is to be offered in 1911 by a Belgian technical so-ciety, L'Association des Ingenieurs Electriciens Sortis de l'Institut Electrotechnique Montefiore. The prize bears the name "Fondation George Montefiore Levi" and is the gift of the founder of the Institut Electrotechnique Mon-tefiore, the technical school from whose graduates the society named above takes its members. The rules of the awarding of the prize, abstracted from the advance cir-cular, are as follows:

The prize is to be awarded once every three years, the first time being in 1911. In this year it will amount to about 20,000 fr. It is to be awarded by a jury for the best paper on the scientific advancement and on pro-gress in the technical application of electricity in all fields, excluding the simpler text-books or compilations of previous works.

Only those papers or books will be admitted which have been brought out within the three years preceding the award.

The jury is to be composed of ten electrical engi-neers, five Belgian and five foreign, under the presi-dency of the head of the Institut Electrotechnique Mon-tefiore, who will be ex-officio one of the Belgian dele-gates.

All papers presented should be in twelve copies, type-written and not signed, but accompanied by some dis-tinguishing mark so that, although anonymity will be preserved, the jury may locate the author after the prize has been awarded.

All communications should be addressed to M. le Secrétaire-archiviste de la Fondation George Montefiore, à l'Hôtel de l'Association, 31 Rue St.-Gilles, Liége, Bel-gium. Each should carry the superscription "Travail soumis au concours de la Fondation George Montefiore, session de 1911."

Although the advance notice makes no special point of it, it would appear that the language in which the paper is written is immaterial, although any reproduc-tion of one or more prize papers will be made in French, the translation to be at the expense of the society.

TWO RIVAL SUBWAY PROJECTS in Montreal are being urged before the Quebec Parliament, and both have been approved by the Railway Committee.

AN OIL PIPE-LINE from Bakersfield to Mojave, Cal., is said to be projected by the Southern Pacific Ry. Co., to save the hauling of fuel for locomotives over the Tehachapi Pass. The pipe-line will be 68 miles in length, with pumping stations every ten miles. It will be of 10-in. rifled pipe, of the type already used for carrying the heavy California oils.

COMPETITIVE RAILWAY CONSTRUCTION in the Connecticut Valley, in southern Vermont and New Hamp-shire, by the Grand Trunk and the New York, New Haven & Hartford interests, is probable. The Rhode Island Legislature has passed a bill permitting the Grand Trunk Ry. to build a branch to Providence from its existing Central Vermont line. The railway will have to build its own freight yards, but has the right to joint use of the present passenger station in Provi-dence. The Central Vermont line down the Connecticut Valley has to use tracks belonging to the Boston & Maine system for a considerable distance near Bellows Falls. The control of the Boston & Maine system by the New York, New Haven & Hartford makes it cer-tain that the use of these tracks will be denied to the Central Vermont, and the company will therefore have to construct its own line over these sections, but will do so under much difficulty and expense, as the to-pography is unfavorable to additional railway construc-tion.

THE HUDSON BAY RAILWAY SCHEME in Canada is opposed by the Montreal "Gazette" and the Toronto "Globe." The latter journal says:

The real point at issue is whether grain can be carried that way to Europe more cheaply than by other routes, or even as cheaply. Unless that question can be an-swered in the affirmative, a railway from the heart of the Northwest to Fort Churchill or Port Nelson would be a piece of the greatest folly imaginable. . . . . We should undoubtedly know much more about the scheme than we do now, before we throw $25,000,000 into the construction of a railway which might remain merely a monument of rash mismanagement.

INTERNATIONAL DAMS ON THE RIO GRANDE.—Treaty rights, securing privileges to build dams across the Rio Grande between Texas and Mexico, have been sought to provide an ample water supply for irrigable lands on the lower course of the river, American side. The desired treaty, a correspondent writes, was the first step in an enormous irrigation enterprise. A series of dams was to be erected at points within 200 miles of the river mouth and systems of canals and ditches were to carry the water over a great acreage. One such dam was to be erected at Roma, 125 miles above the mouth and another at Zapata, 175 miles up.

A blow to these plans is reported in the attitude of the Mexican Government. It is stated that Mexico is willing that these water-storage dams shall be con-structed along the upper course of the international boundary stream, but desires no obstruction to the reg-ular flow at any point within about 250 miles from its mouth. It is declared that the Rio Grande is navigable for that distance, and to erect dams across it would in-terfere with the passage of boats. The original reso-lution that was drawn by the Mexican Government for introduction in the Mexican Congress exempted the lower course of the Rio Grande for 450 miles from the construction of dams. The distance was later cut down to 250 miles. It is believed that it will be adopted in the modified form, and then forwarded to the United States Government for congressional action. It is re-ported that the resolution provides that the water of the Rio Grande above 250 miles shall be considered common to both nations and that either has the right to erect walls or dams for the irrigation of lands on either bank. In the early days a line of boats made regular trips up the Rio Grande as far as Roma, but owing to the accumulation of sand at the mouth of the river no navigation has been attempted for a long time. Steps are now being taken to establish a deep water port at the mouth of the stream, and this will involve the removal of the bar by dredging or the building of jet-ties, it is stated.

The restriction of 250 miles, as now proposed, reaches to a point a short distance above Laredo. From there all the way to El Paso the valley is narrow and the irri-gation possibilities are limited. It is claimed, however, that several available sites for dams exist along the upper course that would form reservoirs of water suffi-cient to irrigate several hundred thousand acres of higher levels of land, both on the American and Mexi-can sides of the international boundary stream. It is reported that efforts are being made to have the Mexi-can Government still further cut down its restrictions to 50 miles above the mouth of the river.

Personals.

Mr. Paul Shoup has been appointed Assistant General Manager of the Southern Pacific Ry. in charge of electric lines.

Mr. E. H. Wade, Division Master Mechanic of the Chicago & Northwestern Ry. at Chicago, Ill., has been appointed Supervisor of Locomotives at Green Bay, Wis.

Mr. Geo. K. Lowell has resigned his position as Gen-eral Manager of the Ann Arbor R. R. to devote all his time to his duties as a receiver of the Detroit, Toledo & Ironton Ry.

Mr. Edward Wegmann, M. Am. Soc. C. E., who was Consulting Engineer of the old Aqueduct Commission of New York City, has been appointed Chief Engineer of the new Aqueduct Commission.